

University of Dundee

HMS Hampshire 100

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DOI:

[10.20933/100001133](https://doi.org/10.20933/100001133)

Publication date:

2020

Licence:

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Document Version

Publisher's PDF, also known as Version of record

[Link to publication in Discovery Research Portal](#)

Citation for published version (APA):

Rowland, C., Hyttinen, K., Macdonald, R., Wade, B., Turton, E., Fitzsimmons, C., Haynes, P., & Crofts, D. (2020). *HMS Hampshire 100: Survey Report*. University of Dundee. <https://doi.org/10.20933/100001133>

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HMS HAMPSHIRE 100

Survey Report

Rod Macdonald, Ben Wade, Emily
Turton, Paul Haynes, David Crofts,
Professor Chris Rowland

HMS HAMPSHIRE 100 Survey Report



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Location: Atlantic Ocean, waters west of Orkney, Scotland

GPS Coordinates: Lat. 59°07.065'N, Long. 03°23.843'W

ISBN: 1 899837 82 5

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First published in 2020

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Report to be cited as:

Macdonald, Wade *et al* (2020) HMS HAMPSHIRE 100 Survey 2016, Survey Report 2020

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Weights & Measures

British warships of this era were built and measured using the imperial system. Their guns are described using both weight and measurements. German ships of the same era were described using the metric system.

This report uses traditional imperial measurements to describe the size of the ship, and uses the traditional imperial weight/size to describe the guns aboard. A conversion table is included below.

- length is measured in feet (') and inches (") 1 foot = 12 inches (1' = 12")
- 1 inch = 2.54cm
- 1 foot = 0.3048m
- 1 yard = 3'/0.9144m
- 1 pound = 0.436kg
- lbs = pounds
- kg = kilograms
- m = metres
- M = miles
- NM = nautical miles
- km = kilometres
- 1 M = 1.6093 km
- 1 x NM = 1.853 km
- 1 x metric tonne = 1000 kg
- 1 x long ton = 1.0160 metric tonnes

HMS HAMPSHIRE

Length: 473'6"/144.3m

Breadth: 68'6"/20.89m

Maximum Draught: 25'6"/7.77m

A note on the time of the sinking

British Summer Time was first introduced to the UK in March 1916. This led to widespread confusion and subsequently the time of HMS HAMPSHIRE hitting the mine is recorded incorrectly in some historical records. British Summer Time (BST) is today described as Daylight Saving Time (DST). Greenwich Meantime Time (GMT) is today described as Universal Time (UT).

Research conducted by local historians ahead of the publication of the book *HMS Hampshire: A Century of Myths and Mysteries Unravelling* concluded that the ship sank at 2040 BST/1940 GMT which is the equivalent today of 2040 DST/1940 UT.

1. Expedition Overview

HMS HAMPSHIRE was a British 10,850-long tons pre-dreadnought Devonshire-class armoured cruiser launched on 24th September 1903, completed on 15th July 1905 and commissioned one month later. She fought at the Battle of Jutland on 31st May & 1st June 1916 before returning to the Royal Navy Grand Fleet base at Scapa Flow in Orkney, off northern Scotland.

On 5th June 1916 she departed Scapa Flow on a secret mission carrying the British Secretary of State for War, Lord Kitchener, and his staff to Archangel in northern Russia to discuss war aims and strategy. En route, some 1.5 nautical miles north west of the sheer cliffs of Marwick Head, north west Orkney, at approximately 2040hrs BST, she struck a mine laid by the Type UE 1 German submarine U 75 early on the morning of 29th May 1916 during German preparations for the Battle of Jutland. HMS HAMPSHIRE settled quickly by the head, rolling over to starboard. She capsized and sank some 15 minutes after hitting the mine. 737 men were lost, including Lord Kitchener and his staff – there were only 12 survivors. Great controversy raged at the time and for many years after as to the cause of the explosion and many speculative publications as to the cause of the sinking followed.

The wreck was designated a Controlled Site under the Protection of Military Remains Act 1986 (Designation of Vessels and Controlled Sites) on 30th September 2002 and no diving has been permitted on her since that date.

Rod Macdonald was granted a licence in 2016 by the UK Secretary of State for Defence to conduct an underwater diver survey of the wreck for the 100th anniversary of her sinking, and co-organised the expedition with Paul Haynes, Emily Turton and Ben Wade. Specialist divers conducted underwater surveys of the entire site using underwater mapping and forensic diving techniques. The wreck was documented using videography, stills photography and 3D photogrammetry.

1.1 Acknowledgements

The expedition organisers Rod Macdonald, Ben Wade, Emily Turton and Paul Haynes express their sincere thanks to everyone who supported this project - to those who gave their time and expertise freely, we are forever in your debt. Together we have helped ensure that HMS HAMPSHIRE will be remembered now and into the future.

The expedition organisers would like to offer our specific thanks to:

Remote Survey: Kevin Heath of Sula Diving.

Dive Team: Rod Macdonald, Paul Haynes, Emily Turton, Ben Wade, Marjo Tynkkynen, Prof Kari Hyttinen, Immi Wallin, Prof Chris Rowland, Paul Toomer, Greg Booth, Gary Petrie, Mic Watson, Brian Burnett. Boat Crew: Russ Evans, Ross Dowrie and Chris Woodhouse.

Consultation in Munitions and Explosive Effects: David Crofts.

Our thanks also go to: The Ministry of Defence, The Explorers Club, Orkney Marine Services, National Maritime Museum, Imperial War Museum (IWM), NAVY SEC-3rd SECTOR HERITAGE.

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The ship's plans are reproduced with the kind permission of the National Maritime Museum, Greenwich, London.

1.2 Purpose of Report

The purpose of this report is to disseminate the information gathered by the HMS HAMPSHIRE 100 Survey. This survey is the most comprehensive conducted to date on HMS HAMPSHIRE and the imagery gathered brings the ship to the surface for non-divers and

future generations. The report describes HMS HAMPSHIRE, her construction, service history and loss. A detailed description of the survey design and methodology are included.

2. Expedition Objectives

HMS HAMPSHIRE is a famous shipwreck of international historical importance on which diving has been prohibited since 2002. There is little imagery of the wreck in existence and the current condition of the wreck was unknown, in particular the damage caused by the mine and subsequent salvage activities.

The main objective of the HMS HAMPSHIRE 2016 expedition was to visually document the wreck at 100 years underwater using stills photography, video and by mapping it in detail using the latest 3D photogrammetry techniques. The expedition objectives were;

1. To ascertain the present condition of the wreck;
2. To undertake a detailed survey;
3. To compile an extensive catalogue of stills and video imagery;
4. To produce a survey expedition report for future historical reference;
5. To raise public awareness of the historical significance of the sinking;
6. To foster positive relations with government and shipwreck heritage bodies.

The results for the first time reveal the extent of the damage caused by the mine and subsequent commercial activity and offer new insights into the sinking of HMS HAMPSHIRE and how she came to lie on the bottom.

The Expedition members were;

<i>NAME</i>	<i>ROLE</i>
-------------	-------------

- | | |
|------------------------------|--|
| 1. Rod Macdonald, FI'15..... | Expedition Leader & videographer |
| 2. Paul Haynes, MI' 15 | Expedition Organiser. Diving Safety Officer |
| 3. Emily Turton, FI'18..... | Expedition Organiser. Photography lighting support |

4. Ben WadeExpedition Organiser. Survey diver & videographer
5. Brian Burnett.....Survey diver & videographer
6. Prof Chris RowlandSurvey diver & 3D photogrammetry
7. Gary PetrieSurvey diver & diving support
8. Greg BoothSurvey diver & diving support
9. Immi WallinSurvey diver & 3D photogrammetry
10. Prof Kari HyttinenSurvey diver & 3D photogrammetry
11. Marjo TynkkynenSurvey diver & stills photography
12. Mick WatsonSurvey diver & diving support
13. Paul Toomer, MI'18Survey diver & diving support

MV Huskya Crew

1. Ben Wade – owner & skipper
2. Emily Turton – owner & skipper
3. Russ Evans - skipper
4. Ross Dowrie - crew
5. Chris Woodhouse - crew
6. Kevin Heath FI'18– sidescan sonar



Figure 1: The Expedition team with The Explorers Club (TEC) Flag No 192 in front of the starboard propeller of HMS HAMPSHIRE outside Scapa Flow Visitor Centre and Museum on the island of Hoy, Orkney.

Left to right; Ross Dowrie, Paul Toomer, Russ Evans, Gary Petrie, Kevin Heath, Immi Wallin, Emily Turton, Ben Wade, Paul Haynes, Brian Burnett, Rod Macdonald, Marjo Tynkkynen, Greg Booth, Kari Hyttinen, Prof Chris Rowland, Mick Watson.

Paul Haynes MI'15 (left) and Rod Macdonald FI'15 (right) hold TEC Flag No 192.

(Image courtesy of Marjo Tynkkynen)

3. HMS HAMPSHIRE

3.1 Construction

The Devonshire-class armoured cruiser HMS HAMPSHIRE, named after the English county, was laid down on 1st September 1902 by Armstrong Whitworth at their Elswick shipyard in Great Britain. The Devonshire-class vessels were provided under the 1901/02 programme in an attempt to improve on the preceding Monmouth-class armoured cruiser design without an excessive increase in size. More powerful 7.5-inch main armament guns were installed in place of six of the smaller main armament 6-inch guns of the Monmouth-class. The vertical main armour belt along either beam was increased to a 6-inch thickness and reduced in height by 12". The class was contemporary with the King Edward VII-class battleships.

HMS HAMPSHIRE was launched on 24th September 1903 and completed on 15th July 1905, and was one of six such vessels in her class. She carried a standard peacetime ship's complement of 610 officers and men.

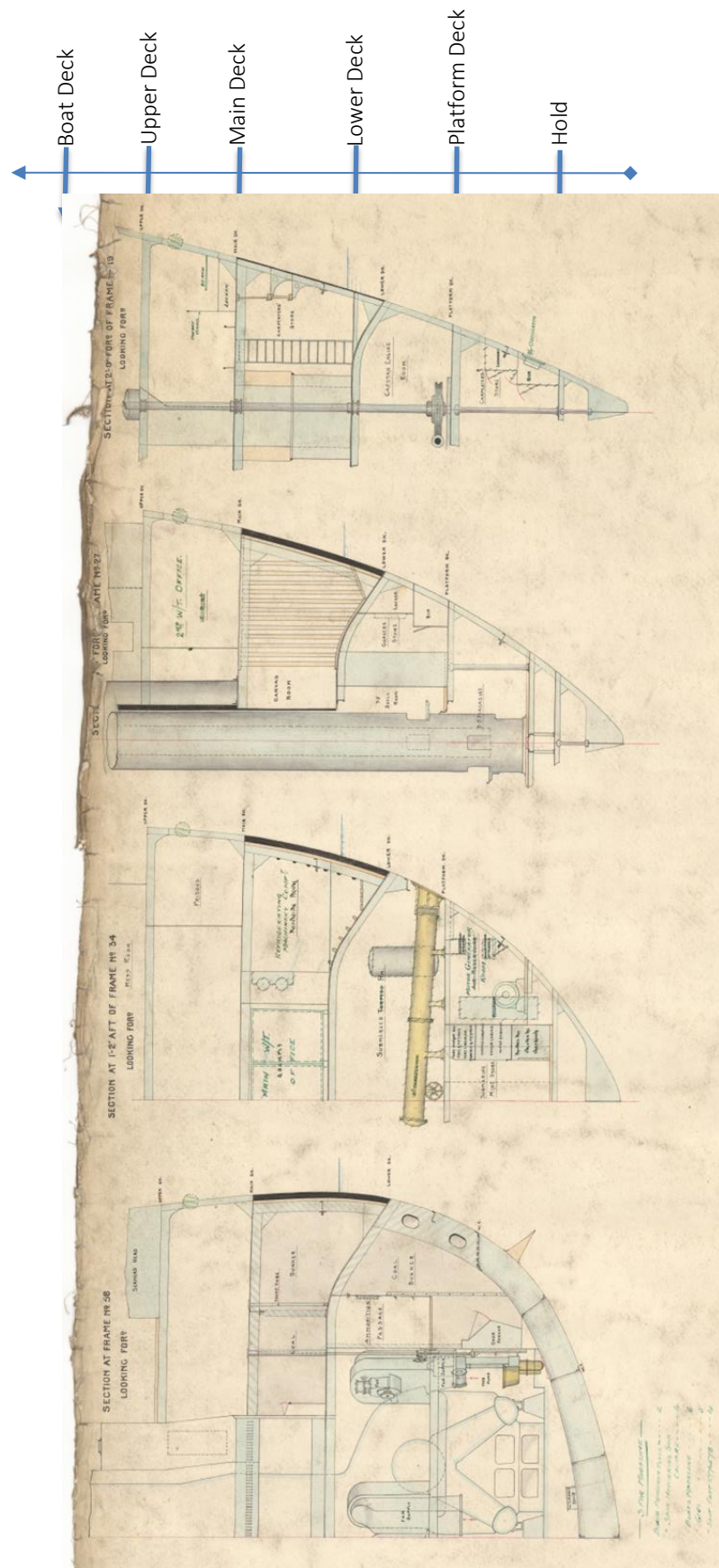
3.2 Design

HMS HAMPSHIRE was designed to displace 10,850 long tons. The ship had an overall length of 473' 6", a beam of 68' 6" and a deep loaded draught of 25' 6".

HMS Hampshire had six decks marked on the ship's plans as:

- Boat Deck
- Upper Deck
- Main Deck
- Lower Deck
- Platform Deck
- Hold

Figure 2: HMS HAMPSHIRE deck levels



3.3 Propulsion

HMS HAMPSHIRE was powered by two 4-cylinder triple-expansion steam engines, each driving one shaft which produced a total of 21,000 indicated horsepower (16,000 kW) and gave a maximum speed of 22.4 knots (25 mph). Her two manganese bronze propellers had a diameter of almost 15' 9".

Seventeen Yarrow and six cylindrical Scotch Marine Boilers powered her two steam engines and she carried 1,745.7 long tons of coal as fuel.

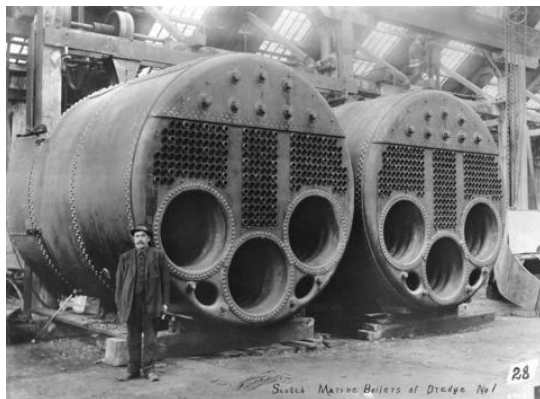


Figure 3: Scotch fire-tube cylindrical marine boiler. The hot gases from the fireboxes pass through thin pipes heating the surrounding water

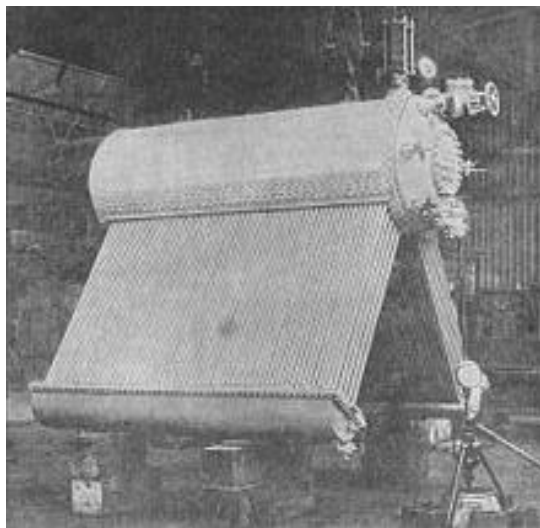


Figure 4: A Yarrow boiler with flue and outer casing removed. Two banks of straight water tubes are arranged in a triangular row with a single furnace between them. A single high-pressure steam drum is mounted at the top and smaller water drums at the bottom of each bank of tubes

3.4 Armament

HMS HAMPSHIRE was fitted as constructed with the following armament.

1. Four single Breech Loading (BL) 7.5-inch Vickers Mk 1 naval guns,
2. Six single BL 6-inch Vickers Mk VII naval guns,

3. Eighteen Quick Firing (QF) 3-pdr Hotchkiss guns,
4. Two single 12-pdr guns,
5. Two single submerged torpedo tubes.

3.4.1 Main 7.5-inch Battery

In an attempt to improve on the Monmouth-class armoured cruiser design without an excessive increase in size, the Devonshire-class armoured cruisers were originally designed to be fitted with two single 7.5-inch gun turrets set on the centre line of the ship, one in front of the bridge and one towards the stern abaft the superstructure, in place of the single 6-inch gun turrets of the Monmouth-class cruisers.



Figure 5: HMS HAMPSHIRE

While under construction, however, two more 7.5-inch wing turrets were added abreast the foremast on either side of the ship on the Upper Deck in place of the superfiring two storey 6-inch casemates of the Monmouth-class. These 45-calibre 7.5-inch Vickers Mk 1 guns were in service with the Royal Navy between 1905 and 1920 and were only mounted on *Devonshire*-class cruisers. They were superseded by the 50-calibre Vickers 7.5-inch Mk II weapon. The barrel length was 28' and the gun fired a 200-lbs shell to a range of about 13,800 yards (7.8 miles).



Figure 6: The Vickers BL 7.5-inch Mk I naval gun

HMS HAMPSHIRE's main armament as constructed therefore consisted of four BL 7.5-inch Vickers Mk I guns mounted in four single-gun turrets.

1. 'A' turret was positioned on the centre line of the Boat Deck (forecastle) forward of the bridge.
2. 'Y' turret on the centre line aft of the superstructure on the Upper Deck.
3. 'P' turret was positioned as a wing turret on the Upper Deck on the port side abreast the foremast.
4. 'Q' turret was positioned as a wing turret on the Upper Deck on the starboard side abreast the foremast.



Figure 7: Starboard view of HMS HAMPSHIRE

The forward 7.5-inch 'A' turret gun can be seen on the Boat Deck and the starboard 7.5-inch 'Q' turret gun can be seen abreast the bridge superstructure on the Upper Deck. The aft superfiring twin 6-inch casemate guns are located on the side of the hull abeam the main (aft) mast.

The ship's plans reveal that the forward 7.5-inch magazines and shell rooms surrounded the torpedo rooms.

3.4.2 Secondary Battery

As constructed, six BL 6-inch Vickers Mk VII guns were initially arranged in two superfiring two-storey casemates, one on either beam towards the stern and a single casemate on either beam amidships.

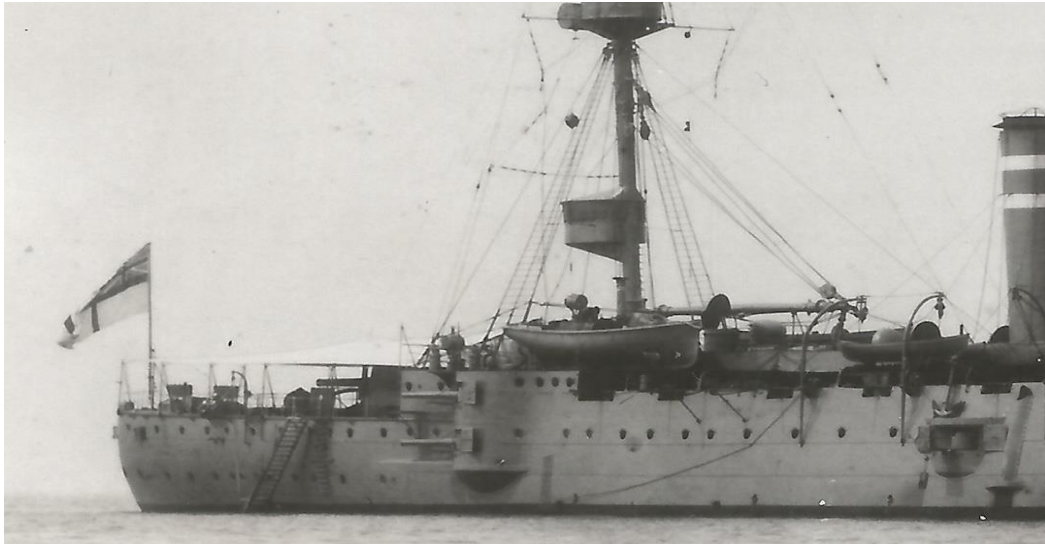


Figure 8: Aft view of HMS HAMPSHIRE showing twin superfiring casemate just abaft the main mast

3.4.3 Casemate Gun Nomenclature – (from ship's drawings)

Stern casemates

- X3 starboard lower gun (Main Deck)
- X1 starboard upper gun (Upper Deck)
- Y3 port lower gun (Main Deck)
- Y1 port upper gun (Main Deck)

Midships casemate

- X2 starboard gun (Main Deck)
- Y2 port gun (Main Deck)

The Mark VII gun was introduced on Royal Navy Formidable-class battleships in 1898. The gun weighed 16,572-lbs excluding casemate protection and its barrel bore was 22' 4.5" (6.9m).



Figure 9: Vickers BL 6-inch Mark VII naval gun (seen here on HMS KENT)

A gun crew of nine was required to operate this gun and it fired a 100lb common Lyddite High Explosive (HE) shell with a maximum range of approximately 12,200 yards (6.9 miles).

Lyddite was formed when Picric Acid was fused at 280°F and allowed to solidify to produce a dense yellow substance that was not affected by moisture. When Lyddite shells detonated they fragmented into small pieces in all directions with no incendiary effect. For maximum effect a delayed fuze allowed the shell to penetrate before exploding inside the enemy target.

Two of these Mk VII 6-inch guns, X2 and Y2 were mounted on the Main Deck in a single casemate on either side of the hull amidships. The remaining four were mounted in two, two-storey casemates, set one on either side of the ship towards the aft portion of the vessel just abaft the main mast. The guns were set one directly above the other in a superimposed firing position, the upper gun being on the Upper Deck with the lower gun on the Main Deck. It was found in practice that these guns were only usable in calm weather with the lower gun being of little use.

The four lower guns on the Main Deck were therefore de-mounted between 10th January and 16th February 1916 in Belfast. They were fitted with gun shields and installed on the Upper Deck, replacing four of the Hotchkiss 3-pdrs, which were landed.

The lower casemate openings were then plated over to improve sea keeping.

3.4.4 Ancillary weapons

HMS HAMPSHIRE was also fitted at the time of her construction with;

- (a) Two single 12-pdr 8cwt guns that could be demounted for service ashore.
- (b) 18 QF 3-pdr Hotchkiss guns set nine along either side of the mid-section of her beam between main mast and foremast. These 40-calibre QF guns were in use with the Royal Navy between 1886 and the 1950s. They had a barrel length of 6' and fired a 3.3lb common Lyddite shell, an armour piercing shell or a common pointed shell. They had a rate of fire of 30 rounds per minute with a range of 4,000 yards (2.27 miles). They were intended as a defence against fast enemy torpedo boats attacking her beam. Eight of these QF 3-pdr guns were subsequently removed to make way for the four Mk VII 6-inch guns demounted in Belfast from their casemates between 10th January – 16th February 1916.

Some or all of the older Hotchkiss 3-pdr guns were replaced with the newer Vickers QF Maxim 3-pdr guns (which came into production in 1905). It was a more powerful successor to the Hotchkiss QF 3-pdr with a propellant charge twice as large, a rate of fire of 20 rounds per minute and a greater range of 5,600 yards (3.2 miles).



Figure 10: Vickers 3-Pr Mk II gun from HMS HAMPSHIRE outside the Scapa Flow Visitor Centre & Museum in Hoy

- (c) Two broadside submerged 18-inch torpedo tubes fitted one either side of the vessel just forward of the bridge. Torpedo hatch doors in the hull plating opened to allow a ram to project laterally from the vessel's beam for the full length of the torpedo and thus allow it to be fired safely without jamming in the tube. HMS HAMPSHIRE carried nine 18-inch Mk V torpedoes and four 14-inch Mk XI torpedoes.

3.5 Armour

3.5.1 Vertical armour

The ship's waterline vertical main armour belt ranged from a maximum thickness of 6" to 2" of hard-faced nickel-chromium cemented steel armour, which had great resistance to punching through by projectiles. The belt was closed off at the stern end by a 5-inch transverse bulkhead located at frame No 162 just aft of the stern casemates. There was no forward armoured transverse bulkhead forward of the foremast.

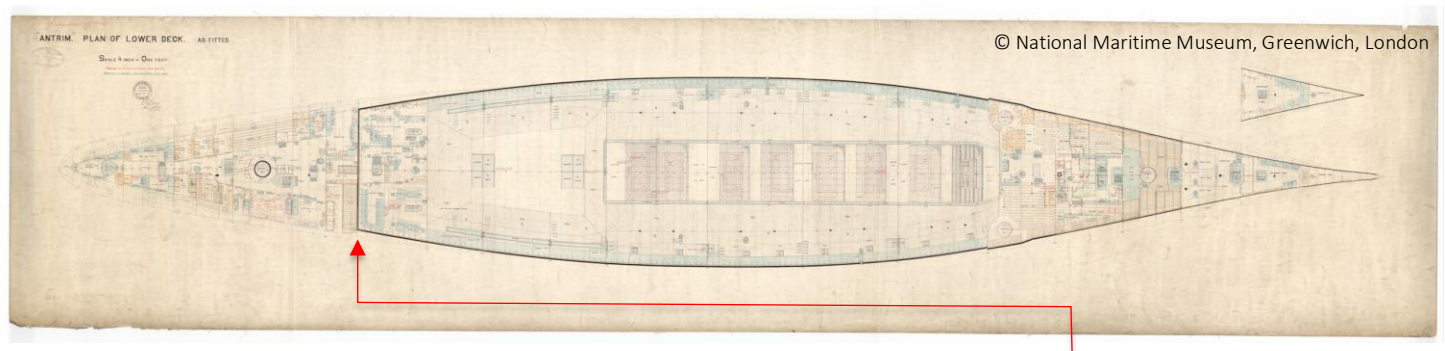


Figure 11: Ship's plan detailing armour belt, note transverse bulkhead at frame No 162

3.5.2 Horizontal armour

The horizontal non-cemented deck armour was of similar composition to the main belt armour but did not have the hardened face. It was much thinner than the vertical armour since at the expected short fighting ranges at the time of her construction, projectiles would have a small angle of descent. The horizontal armour ran the full length of the ship on the Lower Deck and ranged in thickness from 0.75 – 2".

3.5.3 Conning tower

Conning towers of this period were usually made from cast steel because of their complex shape. HMS HAMPSHIRE's conning tower was 12" thick.



Figure 12: Malta, c1912

3.6 Pinnace

HMS HAMPSHIRE carried many ship's boats of varying sizes from 16ft – 56ft in length. The ship's plans, as fitted, detail the following:

- 1 x 26' Cutter,
- 1 x 30' Cutter,
- 2 x 32' Cutter,
- 1 x 27' Whaler,
- 1 x 30' Gig,
- 1 x 16' Skiff Dinghy,
- 1 x 56' Steam Pinnace,

- 1 x 40' Steam Pinnace,
- 1 x 36' Sailing Pinnace,
- 1 x 42' Sailing Launch,
- 1 x Balsa Life Raft.

In addition, she would have carried several Carley life rafts.

All boats were stowed on the Boat Deck between the main mast and foremast. They were launched using various booms and derricks. The steam pinnaces were an integral part of Royal Navy ship to ship, and ship to shore transfer. They were capable of being armed and were powered by a steam engine and small boiler. Both of HMS HAMPSHIRE's steam pinnaces were stowed next to each other on the starboard side.



Figure 13: One of HMS HAMPSHIRE's steam pinnaces

4. Service History

1905: On completion, HMS HAMPSHIRE was initially assigned to the 1st Cruiser Squadron of the Channel Fleet together with most of her sister Devonshire-class vessels.

1908: HMS HAMPSHIRE was refitted at Portsmouth Royal Dockyard in December 1908.

1909: Assigned to the reserve Third Fleet in August 1909.

1911: Re-commissioned in December 1911 and assigned to the 6th Cruiser Squadron of the Mediterranean Fleet.

1912: Transferred to the China Station.

1914: When World War I began, HMS HAMPSHIRE was operating from Wei Hai Wei, assigned to the small squadron led by Vice Admiral Martyn Jerram, Commander-In-Chief of the China Station. Operating with the armoured cruiser HMS MINOTAUR and the light cruiser HMS NEWCASTLE she was ordered to destroy the German radio station at Yap in the Caroline Islands of the western Pacific Ocean. En route, the squadron captured the collier SS Elspeth on 11th of August and sank her. HMS HAMPSHIRE was by this time too short on coal to reach Yap and she was consequently detached and sent back to Hong Kong with the crew of the Elspeth.

At the end of August 1914, she was ordered south to the Dutch East Indies to search for German shipping and the German raider, the light cruiser SMS EMDEN.

On 14th September 1914, HMS HAMPSHIRE was tasked to the Bay of Bengal to search for SMS EMDEN and remained there for three months. SMS EMDEN sighted the immensely more powerful HMS HAMPSHIRE off Sumatra but managed to elude her and went on to sink a succession of Allied vessels before being tracked and set upon by the Australian light cruiser HMAS SYDNEY on 9th November near the British Cocos Islands.

Released on 9th November from her Bay of Bengal tasking, HMS HAMPSHIRE then escorted an ANZAC troop convoy through the Indian Ocean and Red Sea to Egypt.

In December 1914, HMS HAMPSHIRE was refitted in Gibraltar before returning home to the UK for service with the Grand Fleet.

1915: HMS HAMPSHIRE was assigned the 7th Cruiser Squadron in January. On 1st July 1915 she survived an attack from the German submarine U 25 in the Moray Firth when the enemy torpedo failed to explode. In November she escorted shipping in the White Sea of northern Russia.

1916: HMS HAMPSHIRE returned to British waters and participated in the Battle of Jutland on 31st May 1916 with the 2nd Cruiser Squadron. During the battle she was not engaged by the enemy. HMS HAMPSHIRE fired four salvos at the German II Scouting Group, all fell short of their targets. She fired at suspected German submarine periscopes throughout the day.

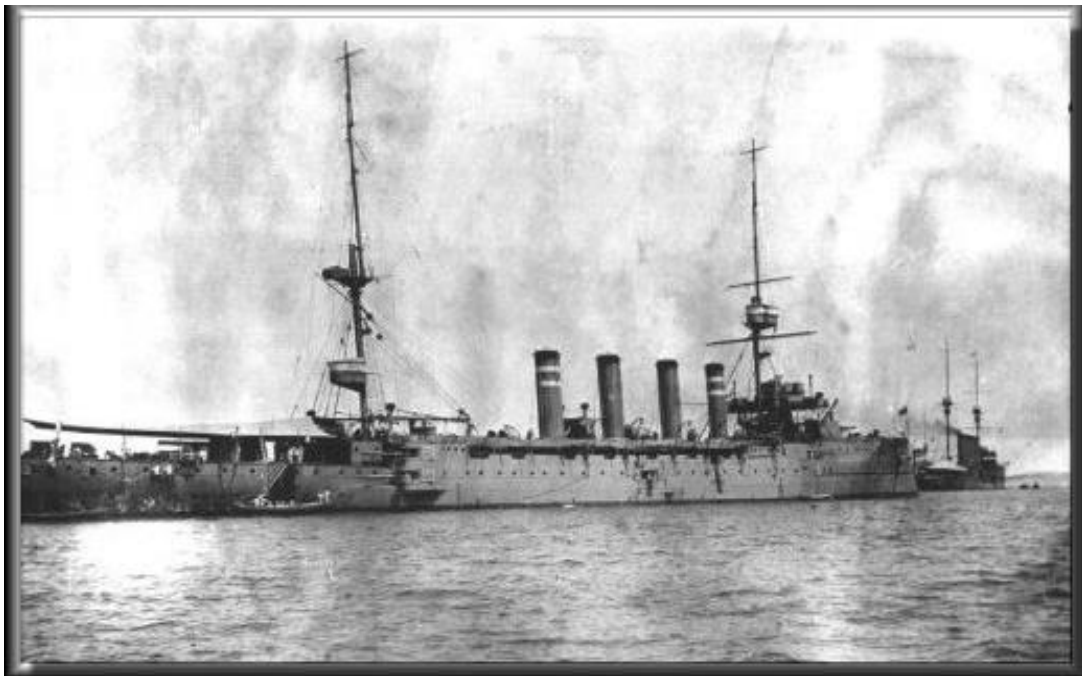


Figure 14: Starboard quarter view of HMS HAMPSHIRE showing aft twin superfiring 6-inch casemate.

5. Sinking

The name of one of Britain's most famous war heroes, Field Marshal Horatio Herbert Kitchener, the British Secretary of State for War, and that of the ship on which he perished, HMS HAMPSHIRE are forever linked with Orkney. For, off the 200' high cliffs of Marwick Head on the north west coast of the Orkney Mainland, HMS HAMPSHIRE, carrying Lord Kitchener

on a voyage to the port of Archangel in northern Russia, struck a mine laid by U 75 and sank with great loss of life.

The series of defeats which had overwhelmed Russia on the Eastern Front during 1915 as German and Austro-Hungarian armies advanced had made it imperative for a high-ranking British Minister to go and examine the situation. Lord Kitchener, the creator of Britain's new volunteer army and organiser of Western Front resistance, would go. Russia had demanded huge consignments of munitions and Kitchener had the experience to gauge how far Britain's factories could assist. Two civil servants from the Ministry of Munitions were given temporary army ranks in order to accompany the party, Lt Col LS Robertson and Brig Gen H F Donaldson. The armoured cruiser HMS HAMPSHIRE was selected for the arduous voyage. At 473' 6" long, she was a strong, powerful warship, well suited to the ill-fated voyage through the dangerous seas around the north cape of Norway to Archangel.



Figure 15: Lord Kitchener (left, both images), c1914

Lord Kitchener had been the driving force behind Britain's recruitment campaign in the early years of World War I. He was the face of the iconic 'YOUR COUNTRY NEEDS YOU' poster. By 1916, however, he was being openly criticised for his war tactics and beliefs.



Figure 16: One of the most iconic images of the First World War, Kitchener was the face of this recruitment campaign

At the beginning of June 1916, Kitchener travelled to Thurso and on 5th June he crossed a stormy Pentland Firth from Thurso to Scapa Flow in the destroyer HMS OAK. He had never been a good sailor and was unwell during the crossing. He was received aboard HMS IRON DUKE by Admiral Jellicoe and the flag officers of the British Grand Fleet and listened with interest at lunch as they recounted the events of the Battle of Jutland, which had taken place only a few days earlier.

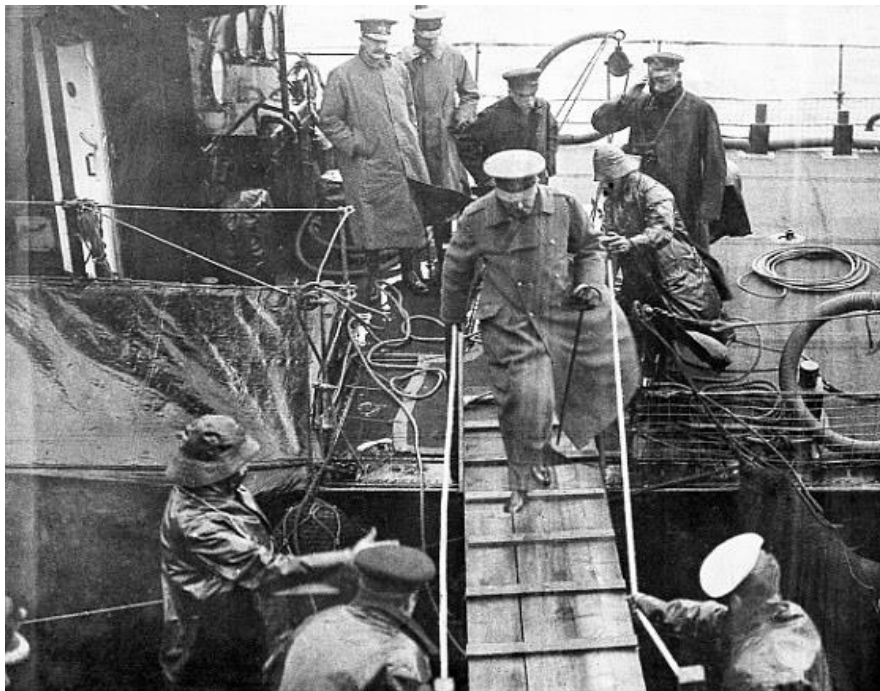


Figure 17: Lord Kitchener crossed from HMS OAK to HMS IRON DUKE for lunch with Admiral Jellicoe and his staff on 5th June 1916 before HMS HAMPSHIRE's departure for Russia. The day is already wet and windy with sailors in oilskins

The commander of HMS HAMPSHIRE had received his sailing orders the day before. She was to depart Scapa Flow on 5th June for Archangel in northern Russia – a journey of 1,649 miles. She was to pass up the east side of Orkney on a route that was regularly swept for mines and to maintain a speed of not less than 18 knots up to Latitude 62°N. She was instructed to pass midway between Orkney and Shetland and keep not less than 200 miles from the Norwegian coast on her journey north. She would have a protective screen of two destroyer escorts as far north as Latitude 62°N, just to the north of Bergen. From there she would proceed alone at 16 knots, zigzagging to avoid torpedo attack. She was rumoured to be carrying gold to help fund the Russian war effort.



Figure 18: The route to Archangel in the White Sea of northern Russia finally selected for HMS HAMPSHIRE

On the day of departure, the weather worsened and by the afternoon, a gale was blowing from the north east. A heavy sea was running along the east coast, making minesweeping difficult. The Admiralty felt that the heavy sea would make it difficult for HMS HAMPSHIRE's two destroyer escorts to keep up with the bigger and more powerful cruiser, and there had

also been reports of possible submarine activity to the east. The fateful decision was thus made to re-route HMS HAMPSHIRE and send her along one of the routes up the west side of Orkney.

Of the two available western routes, it was decided to use the route set up in January 1916, which went past the island of Hoy. This route was not regularly swept for mines, but it was believed that no German minelayer would risk operating this close to the heavily protected main British Grand Fleet base. It was thought that this route would give the two smaller destroyer escorts some shelter from the north easterly gale and enable them to keep up with the larger cruiser HMS HAMPSHIRE. At about 3pm, HMS HAMPSHIRE's crew were told for the first time that they were to carry Lord Kitchener and his delegation to Russia.



Figure 19: Route taken by HMS HAMPSHIRE from Scapa Flow

Lord Kitchener's delegation boarded HMS HAMPSHIRE at 4.15pm and the cruiser slipped her mooring buoy and cleared the harbour at about 4.40pm. She steamed out of Scapa Flow, south through Hoxa Sound, and then turned westwards into the stormy weather of the Pentland Firth to rendezvous with her escort destroyers, HMS VICTOR and HMS UNITY, off Tor Ness on the south west of Hoy. By 5.45pm she had picked up the two escort destroyers, which fell into line astern.

The prevailing weather conditions had however been misinterpreted, for within an hour of slipping her buoy, the storm centre had passed overhead, and the wind backed sharply to the north west. The conditions now facing HMS HAMPSHIRE and her escorts were exactly the opposite of what had been predicted.

At 6.05pm, the smaller and less powerful destroyer HMS VICTOR signalled that she could only maintain 15 knots.

At 6.10pm HMS UNITY signalled that she could only maintain 12 knots, and shortly afterwards at 6.18pm, signalled that she could only make 10 knots. At 6.20pm, HMS HAMPSHIRE signalled that HMS UNITY should return to base.

Shortly thereafter, HMS VICTOR signalled that she could not maintain a speed greater than 12 knots, and at 6.30pm, HMS HAMPSHIRE signalled that she should also return to base. The destroyers were off the entrance to Hoy Sound when they turned for home. HMS HAMPSHIRE went on alone, fighting the fury of the force 9 nine severe gale and its 22-33' high swell.

HMS HAMPSHIRE struggled to make progress up the west coast against the gale for two hours. She dipped and crashed in the raging seas and the bow splash billowed over her forecastle. She was only able to make 13.5 knots.

At about 8.40pm, when she was around 1.5 miles from shore between Marwick Head and the Brough of Birsay, a rumbling explosion suddenly shook the whole ship as she hit a mine. A hole was torn in her keel between her bow and the bridge, the helm jammed and the lights

gradually went out as the power failed. With no power she could make no radio contact with the shore to call for assistance.

Survivors later recounted that the explosion seemed to have taken place on the port side, just forward of the bridge. She immediately began to settle into the water and a cloud of brown, suffocating smoke poured up from the fore part of the ship, making it difficult to see on the bridge.

Most of the crew had been down below decks and nearly all the hatches were battened down and shored up for the night. The crew began to knock out the wedges and proceed to their stations. The after-hatch to the quarterdeck was open, and as the crew streamed aft away from the explosion, an officer was heard to call out: "*Make way for Lord Kitchener.*" He passed clad in a greatcoat and went up the after-hatch just in front of one of the few survivors and was last seen standing on the deck of HMS HAMPSHIRE. *The Times* of Friday 9th June 1916 reported that Kitchener's party were put in a boat that was subsequently swamped by the sea.

The cruiser settled quickly into the water by her bows, stern lifting slowly out of the water. Her propellers were seen clear of the water, still revolving.

There was no power to work the lifeboat derricks and pinnace booms and so none of the larger boom boats could be hoisted out. Those smaller lifeboats that were lowered into the water were smashed to pieces against the side of HMS HAMPSHIRE by the force of the gale. None of the survivors saw a single boat get clear away from the ship. A number of men took their places in the large lifeboats – which could not be lowered – in the forlorn hope that as the ship went down the boats would float off. However, these boats and crew would be carried down with HMS HAMPSHIRE.

She settled quickly by the bow, listing to starboard. A small explosion took place forward and smoke and flame belched from just behind the bridge. At about 8.50pm, roughly 10 minutes after striking the mine, she was seen to capsize to starboard before disappearing beneath the seas.

Only three oval, cork and wood Carley floats got away from the sinking ship. These rigid Carley floats were made from a length of copper tubing divided into waterproof sections, bent into an oval ring, then surrounded by cork or kapok and covered with a layer of waterproofed canvas. The raft was rigid and could remain buoyant even if the waterproof outer skin of individual compartments was punctured.



Figure 20: Example of Carley floats

One Carley float launched with at least nine men but faced with the severe conditions it was overturned three times, jettisoning the men into the sea. Only six managed to regain their positions, but the raft contained only four men when it came ashore at Skail Bay. Only two survived.

A second, larger, Carley float got away with 40 to 50 men on it. When it made the shore just north of Skail Bay almost five hours later at 1.15am, only four of its occupants had survived the ordeal.

The third Carley float had about 40 men in it when it left the sinking ship and another 30 were picked up from the water. Not all crew were wearing their life preservers, and it was reported that the raft couldn't hold the number of men now on it. An officer ordered those men wearing life preservers to enter the water and swim for shore. Those men left on the raft were drenched and badly affected by wind chill. Most of them were soon suffering from

exposure, losing consciousness or foaming slightly at the mouth. Those that lost consciousness never regained it. When at 1am it finally surged up on to the rocks in a small creek called Nebbi Geo, half a mile north of Skail Bay, there were only six men left alive.

Of the 749 men aboard, only twelve survived. Lord Kitchener and his entire staff perished.

The subsequent search at sea located 13 mines in the vicinity of the sunken vessel. They had been laid at a depth of 9 – 29', deep enough to let smaller vessels such as fishing boats sail over the top and designed to catch only larger, more important vessels. On 22nd June 1916, a Royal Navy minesweeper HM Drifter LAUREL CROWN hit a mine in the same mine field during sweeping operations and sank with the loss of nine of her crew. Her wreck has not yet been found.

It was later revealed that a spread of 34 mines had been laid by the German submarine U 75 on 29th May as part of German plans for what would develop into the Battle of Jutland, five days before HMS HAMPSHIRE sailed on her final mission. The German High Seas Fleet had put to sea to lure the British Battle Cruiser Fleet out of its anchorage in the Firth of Forth. It was anticipated that the main British Grand Fleet based at Scapa Flow would also put to sea and German submarines would be waiting for it. Three mine-laying submarines, including U 75, were sent out to mine the likely areas the British Fleet would pass and German intelligence was aware of the route that would tragically be used by HMS HAMPSHIRE. U 75 sailed from Germany two days before Jellicoe even knew of Lord Kitchener's proposed journey.

With the death of Lord Kitchener, Germany had unintentionally scored an immense victory that struck at the hearts of the British people. Kitchener may have been out of favour, but he was still a legend. He had led the relief force that had lifted the Mahdi's siege of Khartoum in 1883 in an attempt to save the British war hero General Gordon, and been awarded the title Lord Kitchener of Khartoum. Quickly promoted, he led British forces in the conquest of the Sudan in 1896. He quelled the Boer uprising in South Africa, his aggressive tactics displacing many civilians who were housed in hastily constructed camps, where many died of hunger and disease. His tactics, though successful, were latterly criticised as being overly brutal.

In 1902, following the signing of a peace treaty, he returned home to a rapturous and patriotic welcome and was appointed Commander-in-Chief in India. In 1909 he was promoted to the rank of Field Marshal. At the outbreak of World War I, Britain had turned to its most famous soldier for leadership, and appointed him Secretary of State for War. His loss was an untimely and bitter blow for the nation.

6. The Kitchener Memorial

The Kitchener Memorial, a 48' high stone tower was erected by public subscription on Marwick Head, Orkney Mainland, the closest land point to the scene of the disaster and was unveiled in 1926 to remember Britain's Secretary of State for War, one of the many men who died.



Figure 21: The 200-foot high cliffs of Marwick Head, seen from the Kitchener Memorial

No names of the other casualties of the sinking however appeared on the tower. Orkney Heritage Society, whilst restoring the tower in 2016, erected an adjacent low arc-shaped wall that was engraved with the names of all those lost on HMS HAMPSHIRE - along with the

names of the nine crew of HM Drifter LAUREL CROWN which hit another mine nearby on 22nd June 1916. The wall was unveiled as part of the 100th anniversary commemorations on 5th June 2016.



Figure 22: View of Kitchener Memorial from the south during the 100th anniversary commemorations

7. U 75 Mine Laying Operations

As the Great War began, the main danger to Royal Navy warships was the advent of reliable torpedoes and mines. British dreadnoughts were designed with only a thin protective armour protecting magazines and shell rooms and lacked adequate torpedo defences. This fact would help shape British tactics at the Battle of Jutland in 1916 where Admiral Jellicoe did not pursue the German High Seas Fleet as it tried to make good its escape, fearing an attack by German torpedo boats.

In August 1914, on the declaration of war, the Royal Navy immediately began a distant blockade of the North Sea to cut off vital war supplies and food for Germany. The Imperial

German Navy recognised its numerical inferiority to the British Royal Navy, the dominant naval power at the time. As the British blockade began to bite, German naval strategists stressed the importance of minelaying to sink British ships and thus redress the naval imbalance and by disrupting British supply shipping. German light cruisers and torpedo boats were already designed to deploy mines, and German cruisers carried out several early mine laying sorties near the English coast in 1914 and 1915 that led to the sinking of nearly 100 British vessels.

Almost immediately there was a valuable early German success with the sinking of the British King George V-class dreadnought battleship HMS AUDACIOUS off Northern Ireland on 27th October 1914, just two months into the war. Just over a year later in January 1916, the British pre-dreadnought battleship HMS KING EDWARD VII was lost to a German mine off Cape Wrath.

Realising the potential of the naval mine, in late 1914 the Kaiserliche Marine began to construct a number of ocean-going mine-laying submarines. On 30th January 1916 the Type UE 1-class submarine U 75 was launched at AG Vulcan's yard in Hamburg, one of 10 such boats in her class. She was 56.8 metres long with a beam of 5.9 metres and displaced 755 tonnes surfaced and 832 tonnes submerged. Her diesel engines gave her a surfaced speed of 10.6 knots with a range of 12,681 km at 7 knots. Submerged and running on electric motors she could make 7.9 knots with a range of 133 km at 4 knots. She was fitted with a 105mm deck gun and carried 34 mines.

Kapitänleutnant Curt Beitzen assumed command when she was commissioned on 26th March 1916. U 75 carried a crew of 32 officers and men. The first casualty of her first patrol would be HMS HAMPSHIRE.

Figure 23: U 75 Kapitänleutnant Curt Beitzen



U 75 sailed from Heligoland on 24th May 1916 on her mission to lay mines off north west Orkney and, after skirting round the north of Shetland, she turned her head south west to Orkney. She arrived off the north west coast on 28th May 1916.

She began laying her spread of 34 mines off Marwick Head at 7.00am on 29th May, and had completed mine laying operations by 9.35am when she turned to head north back towards Germany. She arrived back at Heligoland early on 3rd June, the day Kitchener left London for Orkney. U 75 carried Hertz horn contact mines, which were the standard German naval contact mine of WWI and had an explosive charge of 150kg.

Neither BEITZEN nor U 75 would survive the war. BEITZEN was transferred to command U 102 in November 1917, but shortly before the end of the war, on or about 30th September 1918, he died along with the rest of the crew of U 102 when she sank off the Orkney island of Stronsay, whilst attempting to pass through the British Northern Mine Barrage.

U 75 hit a mine off Terschelling on 13th December 1917 on a mine laying mission, with the loss of 23 of her crew.

8. Salvage

Reports of unofficial salvage work on the wreck of HMS HAMPSHIRE began to circulate in 1933. *The Singapore Free Press and Mercantile Advertiser* newspaper of 22nd June 1933 reported that rumours of a secret salvage company, formed to “loot” the wreck, were being circulated in New York by a man called Charles Courtney, who described himself as a “master locksmith.” He claimed to have brought up £15,000 in gold in a chest from the wreck of HMS HAMPSHIRE, before being flung against the side of the wreck for 40 minutes by a violent current, suffering a broken wrist and injured ribs as a result. Consequently, it being so traumatic an event, his hair turned white.

In the 17th December 1933 edition of the British newspaper *The Daily News* it was subsequently reported that a German company was illegally salvaging the wreck of HMS HAMPSHIRE under the heading;

GERMANS SALVAGING HMS HAMPSHIRE

Kitchener's Death-Ship Secretly Raided

The report stated that a German vessel was secretly salvaging HMS HAMPSHIRE and attributed the story to the *Berliner Illustrate Zeitung*. The report narrated that salvage operations were unsuccessfully commenced in 1931 and were restarted in April 1933. The salvage vessel was alleged to have approached HMS HAMPSHIRE with the greatest of secrecy, the Captain taking a roundabout route from Kiel to avert suspicion and cruising along the Norwegian coast before crossing to the Orkney Islands.

The American locksmith Charles Courtney claimed to have been employed by the salvage consortium to dive to the wreck and it was further claimed that \$10,000,000 of gold was situated in six large safes in a small room beyond the Captain's cabin. Charles Courtney published his book *Unlocking Adventure*, published in 1951 (Robert Hale Ltd, London) and a chapter entitled *Kitchener's Gold* is devoted to the 1933 expedition, allegedly funded by a group of undersea financiers led by the Greek arms dealer and industrialist Sir Basil Zaharoff. Courtney narrates a vivid, dramatized and possibly largely fictional account of the subsequent salvage attempt in '385 feet' of water using pneumatic hammers to break off rivet heads before pushing out the rivets and dropping ship's plates to the seabed in order to get into the wreck and locate the safes.

Courtney's narrative was repeated in the American magazine *Cavalier* in 1961, which narrated that the wreck was located in '350 feet' of water and was entered 26 times, with gold recovered.

Much of Courtney's dramatic account is unbelievable, such as when it is narrated that a diver entered the room of the commander of HMS HAMPSHIRE. As the steel door was opened, he claimed that the decomposed bodies of two British officers were found seated at a table in

the airtight room. The vessel is actually upside down. As water swirled into the room, the bodies rose from chairs and drawn by suction, floated past Courtney and vanished in the framework of the sunken ship.

It was also claimed that divers worked by day and by night with the crew of the salvage vessel, maintaining constant vigil lest the suspicions of passing vessels be aroused. Using oxy acetylene cutting apparatus they apparently found the safes in a small anteroom beyond the Captain's cabin and raised £60,000 in gold coins and 20-rouble pieces, along with personal papers relating to Lord Kitchener's Russian mission. Oxy acetylene cannot be used at depths of more than 30', so this part of the account appears incorrect. Courtney narrates that the wreck was largely covered in sand and that water lifts had to be used to clear access to it.

The report continued that three final explosive salvage charges were set off, one causing a secondary detonation of some of HMS HAMPSHIRE's munitions which hurled the divers into the mud, causing a mudslide. Courtney was alleged to have been pinned against a wall by a raging current which resulted in a wall of mud sliding into the vessel and causing the death of two of the salvage divers, a serious case of the bends in another and Courtney having to return to New York where he underwent four operations for ruptures.

HMS HAMPSHIRE sits on an area of clean white sand, shale and historic glacial deposits. The wreck is completely free of any mud, sand or silt deposits and there is no mud bank in the vicinity, so the report is incorrect in that respect.

At page 121 of *The Salvage of the Century* by Ric Wharton (Best Publishing Company, 2000), an alternative and more believable account of this episode is narrated. As the divers were cutting a way into the wreck, it is suggested that they broke through a bulkhead into one of the coal bunkers, which were situated behind the main vertical armour belt on the outer sides of the ship. The divers were buried in an avalanche of coal and two of them perished.

In 1977, 1979 and 1983 the wreck was dived by commercial consortiums who obtained a licence from the UK Ministry of Defence (MoD) to survey and film it. The 500-tonne commercial dive vessel *Deep Diver* owned by Gothenburg Diving Technique was chartered for

15 days from 15th August 1977 by AGUF (Anglo-German Underwater Filming Company) for the purpose of salvaging gold from the wreck. It was believed that 54 tons of gold in bullions and Russian gold roubles were aboard the vessel. British officials and a Notarius Publicus from Lichtenstein were present in case any gold was recovered. Weather and diving logistics frustrated the project and despite the contract being extended from 16 to 21 days, only observation dives were made from a bell and little was achieved.

In 1983 the Aberdeen oilfield diving support vessel Stena Workhorse was engaged by a consortium using 10 divers in saturation aided by a remotely controlled vehicle (ROV). In Wharton's *The Salvage of the Century* he reports that divers found damage caused by the mine that sank HMS HAMPSHIRE, and that the original damaged area had been considerably enlarged. No signs of an explosion from the inside that would have caused her plates to be bent outwards were seen.

Divers from the 1983 survey reported that the starboard propeller shaft had broken at a flange just outside the shaft casing. The bracket close to the propeller, supporting the shaft, was broken at the hull. The starboard propeller itself was lying on the seabed beside the wreck. The diving licence precluded removing items from the wreck, but the divers believed it did not prevent them from recovering items lying on the seabed around it. The prop, a section of shaft and the bearing support were lifted, and the recovery reported to the Receiver of Wreck in Aberdeen. The prop and shaft were offloaded onto the pier at Peterhead when the vessel arrived there on completion of the works. It lay there for more than a year until it was sent to Orkney, where it remains on display at the Scapa Flow Visitor Centre & Museum at Lyness on the island of Hoy.



Figure 24: Starboard prop shaft bearing on display at Scapa Flow Visitor Centre & Museum, Lyness



Figure 25: 12-pdr gun believed to have been recovered from the wreck site in 1983



Figure 26: Salvaged starboard propeller at Scapa Flow Visitor Centre & Museum, Lyness

9. Survey Methods

9.1 Overview

The HMS HAMPSHIRE 100 survey utilised both in-water and remote survey techniques. Sidescan sonar survey techniques provided an overview of the site, including a substantial seabed debris field to the east of the main wreck. An in-water diver survey allowed detailed architectural features and artefacts to be located and documented. HD and 4K video were used for broad scale documentation of the site, whilst underwater stills photography and 3D photogrammetry were employed for recording the site and her features.

The survey took place under Licence No C/001/2016 granted by the UK Secretary of State for Defence. The licence holder was Rod Macdonald and the licence period for the survey ran from 30th May 2016 to 1st August 2016.

All diving took place from the dive charter vessel MV HUSKYAN, owned and operated by team members Emily Turton and Ben Wade.

Thirteen volunteer divers conducted over 100 survey hours on the ship. The survey was self-funded.

9.2 Sidescan

A remote survey was conducted prior to any diving by Kevin Heath of Sula Diving, using sidescan sonar. The purpose of this survey was to identify the extent of the main wreck site and wider debris field in order to plan the in-water diving activity. A digital scanning unit called a towfish is towed behind a boat in the water column above the seabed. The sidescan looks to both sides of the towfish over the seabed producing easily interpreted images of the seabed and objects on it. This survey technique allows large areas of the seabed to be covered quickly and the orientation of the wreck to be accurately charted.

9.2.1 Sidescan: Technical Information, Data Processing and Analysis

The sidescan used was a C-Max CM2 EDF. All sidescan data was post processed using Sonarwiz 6 software, allowing mosaics and contact reports to be generated. Initial analysis of the sidescan data showed the wreck to be lying upside down on a bearing of 310° T on a roughly north west/south east orientation. Her bows were to the north and there appeared to be a depression in the seabed around the bow. A large debris field of sizeable objects was present to the east of the wreck with no objects located to the west of the wreck.



Figure 27: Sidescan sonar of HMS HAMPSHIRE

9.3 Diving Methods

The in-water diver surveys were conducted by a team of technical divers using closed-circuit rebreathers. The team consisted of professional underwater image makers and technical wreck divers.

The site has an average seabed depth of 66 metres, and most dives were conducted with a bottom time of 35 minutes and a run time of 120 minutes. The use of technical diving equipment was key to enabling relatively long bottom-times, thus allowing large areas of the wreck site to be covered in a single dive.

See Appendix I for more detail.

10. Survey Design

10.1 Pre-Dive Survey Research

Archive and anecdotal information was gathered regarding the sinking and subsequent surveys and salvage attempts.

Some early diving video, taken in the late 1990's prior to the wreck's closure, was studied and used to compare corrosion and decay over a 16 – 17 year period.

10.2 Ship's Plans

The ship's plans are housed at the Ship Plans Archive at the National Maritime Museum in Greenwich. A full copy was purchased and formed an integral part of the survey materials. These were used to reference artefacts and structural features.

10.3 Preliminary Diver Surveys

Working from sidescan data, the initial dives concentrated on the main wreck site. The bow and stern were allocated permanent shot lines to provide fixed datums. Working from these datums, divers undertook free swimming around the site and identified key features. After

each dive, divers annotated their findings on a large whiteboard, thus gradually building an overall picture of the site.

10.4 Detailed Diver Survey

Once a basic understanding of the site had been achieved, work began to accurately record the site and document key features.

In addition to surveying the main wreck site, concurrent activity took place to identify contacts located in the debris field to the east of the main wreck. The majority of these contacts were located in isolation. Using the sidescan data, distance and bearings were obtained to some of the outer contacts, and vector diagrams generated. Divers could then use underwater navigational techniques to locate the contact. It became clear as these contacts were investigated that most of these were items that had dropped from the ship as she capsized on the surface, such as three 6-inch guns and two individual Yarrow-type boilers from the ship's pinnaces. Other, more distant and larger objects were revealed to be Norwegian glacial melt boulders deposited there as the ice melted at the end of the last Ice Age.

Team debriefs were held at the end of each day and the findings recorded in a working "ID Spreadsheet" and details added to the whiteboard. This allowed data to be captured in a logical manner, as well as providing a platform to formulate subsequent dive plans.

10.5 Photography and Videography

Both underwater stills photography and videography were used to document the wreck. The survey team included a professional stills photography team. In addition, all survey divers carried small underwater video cameras to capture details during exploratory dives. This information was collated after each dive, enabling specific areas to be identified which were then documented by the professional image takers.

It was important to gather large wide-angle images which gave a broad impression of the ship and to capture images which speak to a non-diving audience. Equally important was the

documentation of small artefacts and specific details in the wreckage which help tell the story of life on board. Other images were gathered to document the explosive effects of the loss.

Marjo Tynkkynen

As a photojournalist Marjo Tynkkynen records reality as it appears in front of her lens. Her images pursue the truth and penetrate through layers of time and history. This same approach was employed in photographing HMS HAMPSHIRE.

Photography equipment:

- Canon 5D mkIII body,
- 16-35mm wide-angle lens & 15mm fisheye lens,
- 2 x Canon Speedlite 580 EXII flashes,
- Light & Motion Sola focus light,
- Subal underwater housing for camera and flashes,
- Diver lighting images with two Scubamafia, 300W, 150° beam (“The Beast”) flood lights.

It was essential that each image captured enough information for the photograph to be readily interpreted. Site familiarisation was key to this process. Consideration was also given to the direction and quality of light in order to create the desired ambiance and to identify which shapes and forms needed to be highlighted. Image composition also explored diver positioning in relation to the subject.

The method employed to record the reality in the underwater environment was as follows:

- The photographer used two powerful flashguns to light the image.
- A second diver operating two 300W floodlights, often from within the image.
- The second diver is often pictured within the image to provide scale and orientation.

All the lights used to capture the images help reveal the visible spectrum of light unaffected by the water. The colour was vital for the viewer to accurately interpret images such as ageing wood, fresh rust, growth on different surfaces and marine life.

The interplay between the lighting diver and photographer was paramount, simple underwater verbal and hand signal communication allowed the photographer to fine tune the floodlighting and diver positioning. Pre-dive planning of each image was essential.

Tynkkynen operated the camera and flashguns on manual mode to find a suitable balance between ambient light and flash. Frequent rotation of the flash arm extensions both created top/bottom light and illuminated the diver in the image. Objects within the image were illuminated by the second diver's floodlights on full or half power, depending on the distance to the camera lens, the degree of ambient light and waterborne particulates.

10.6 3D Photogrammetry

Creating 3D models of archaeological sites using structure from motion (SfM) photogrammetry is an established and well documented method (Green, Bevan & Shapland, 2014). The simplicity of the process and the availability of open source photogrammetry tools has facilitated the digital capture of heritage sites in and around Scapa Flow and other significant global sites above and below the water. Commercially available tools (e.g. Agisoft Photoscan, Reality Capture and Remake) condense the processes involved into a single streamlined package that simplifies the process further.

Underwater sites present specific challenges for photogrammetry. They are often difficult to access, require specialist equipment (e.g. camera housings, lights) and diver training. When the site of interest is beyond the safe range of open-circuit scuba equipment or requires repeat diving, technical dive training, closed circuit rebreathers and mixed gas blends also become necessary.

Alternate remote sensing technology such as multibeam sonar and subsea laser are effective methods to survey shipwreck sites without diver equipment. However, these technologies do

not capture colour information and the resolution and quality of the point cloud data produced can vary significantly. When good quality multi-beam sourced point cloud data is available, this can provide a base map to locate higher detailed and textured photogrammetry data. At the time of this site survey, this multibeam data of the site was not available.

10.6.1 Equipment

A range of camera and lighting equipment was used during the project. When possible, high end mirrorless full frame digital cameras were employed with multiple light sources. This required the coordination of pairs of divers, one camera operator and one lighting operator in support. In sites with low visibility it is necessary to move the camera as close to the target object as possible. This reduces the volume of sediment in the water between the lens and the object. Therefore, high quality wide angle rectilinear lenses produce the best results, a wide field of view with minimal distortion.

The primary photogrammetry team utilised specialist high-resolution video cameras, the camera operator deploying two LED 100W lights and being supported by a team of two lighting assistants, one of whom carried a single LED 1000W specialist video light and the other who carried a 300W video light. 100W is roughly 10,000 lumens so in total 150,000 lumens were used for the photogrammetry.

The camera operator would very slowly pan over sections of the wreck or individual objects. Each one of the hundreds of frames that make up the moving picture images would be from a slightly different angle. The primary photogrammetry team was augmented by support teams operating action cameras (e.g. GoPro) with diving lights, who were tasked with investigating unidentified targets from the sidescan images gathered at the start of the project.

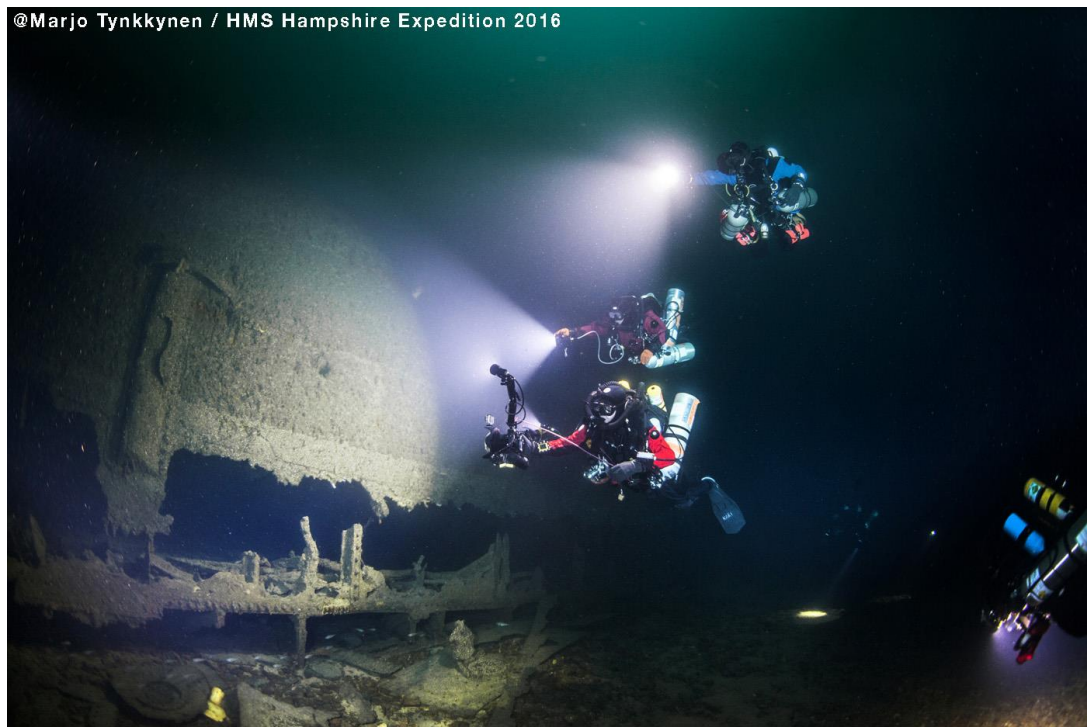


Figure 28: Photogrammetry data capture

10.6.2 The SfM Process

SfM photogrammetry can be created from sequences of still images captured through time-lapse or extracted from video footage. The method adopted for the project was to shoot HD video and sample images at 2-3 frames per second. This method allowed wider coverage and a greater selection of images to choose from. The process involves the identification of common features which are visible in an array of photographs. The photogrammetry algorithm identifies these common features and uses them to triangulate the position of the camera in 3D for each image. From these calculations the spatial position of features in the image can be calculated and a 3D model is produced.

There are a number of distinct steps in the process:

- Record an image sequence with overlapping images;
- Photogrammetry algorithm calculates the relative spatial position of features and creates a sparse point cloud with camera positions;
- Dense point cloud is calculated based on the camera positions;
- A 3D mesh is created from the dense point cloud (optional);
- Images are projected from the camera positions to create a texture (optional);

- The combined mesh and texture can be exported for analysis, visualisation and animation.

There are two stages that are optional. It is possible to produce an accurate dense point cloud that precisely represents the topology and surface texture of the targeted object. The optional stages are necessary when the final output is designed for virtual reality experiences or game engine implantation. These technologies require point cloud data to be converted to polygon meshes.

10.6.3 Software and Post-Processing

SfM image processing was carried out using a combination of Agisoft Photoscan and Reality Capture software. Data was processed onsite using powerful laptop computers and followed up post-survey on HP workstations. The output from this is an extensive library of point cloud data visualising significant features from the wreck site. Data processed on the survey vessel was used to debrief the dive team and identify target areas for attention the following day.

Further processing was carried out overnight to inform the briefing sessions for the subsequent day's survey dive.

The SfM process:

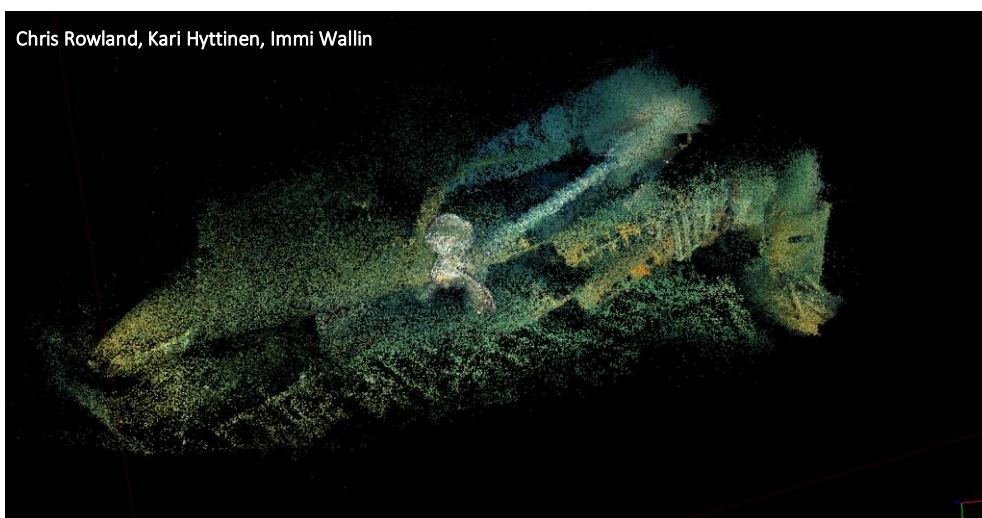


Figure 29: Sparse point cloud of the stern section

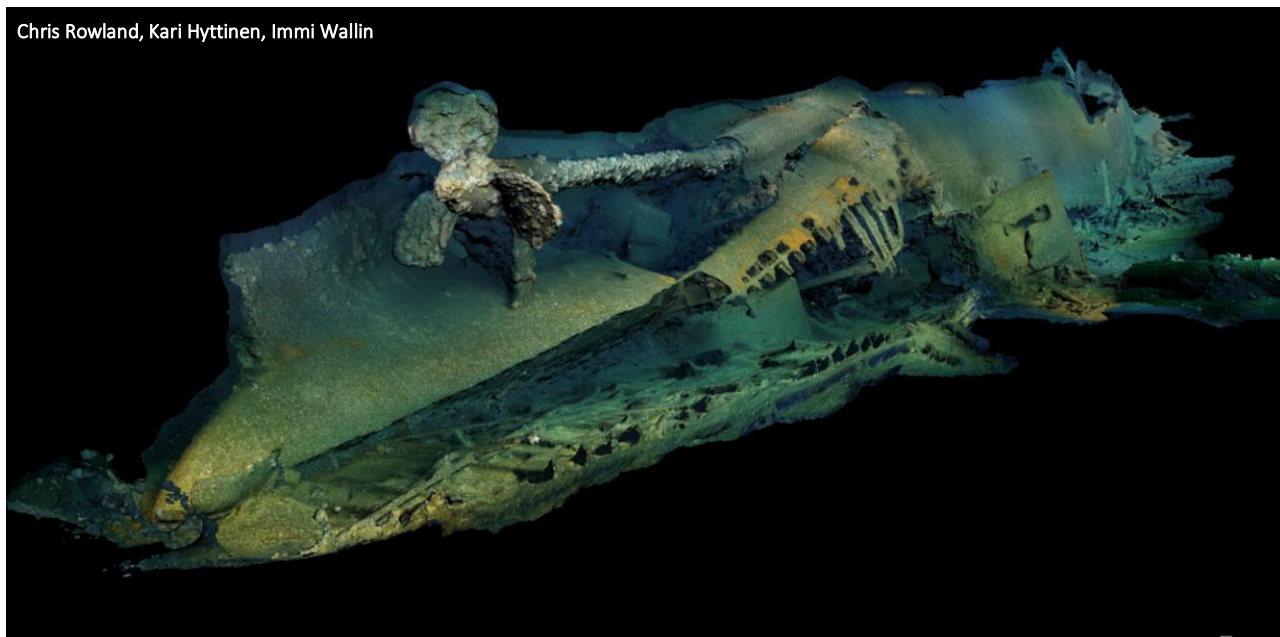


Figure 30: Dense point cloud of the stern section

The whole wreck was mapped in this fashion at large scale and with individual objects of interest such as guns, anchors etc being focused upon in close detail.

10.6.4 Data Distortion

Data distortion can occur when aligning images over a large distance using a long image sequence. This is evident when the 3D model appears to bend when features observed in the original images show straight lines. The effect is caused by small incremental errors in the 3D calculation over distance. To counteract this problem, 1-metre rulers were weighted and placed on the seabed at key features of the wreck. These rulers can then be identified in the recorded image sequences and marked as straight edges with known length in the photogrammetry software. At smaller sites than HMS HAMPSHIRE it is possible to capture multiple rulers within the same image and thus avoid the data bending problem. Unfortunately, in our case this was not possible.

To cover the full extent of the site would have required the placement and recovery of some 200 rulers to cover all sections of the wreck. Therefore, the photogrammetry team focused on capturing major features such as the stern, including remaining propeller and shaft, bow,

secondary guns and anchors and smaller artefacts, such as exposed munitions, and ensured that each section started or passed over at least one strategically placed ruler.

10.6.5 Target Features

Following initial mapping of the site to identify significant features, the photogrammetry team were directed to focus on certain aspects of the wreck. For larger features, multiple dives were required to allow full coverage. Once the main features were captured, smaller targets were identified.

The 3D models produced through the structure from motion process can be viewed from any direction, allowing further analysis after completion of the survey. The process also removes any moving object from the image, so fish and detritus in the water column are not visible in the final 3D model. The critical element in the process is the initial image capture. When resolution image sequences are captured with appropriate depth of focus, they can be reused as photogrammetry algorithms improve in the future and computing power increases.

Data from future surveys could be combined with current data to extend coverage of the site and show any changes occurring to the wreck over time.

11. Survey Results – The Wreck Today

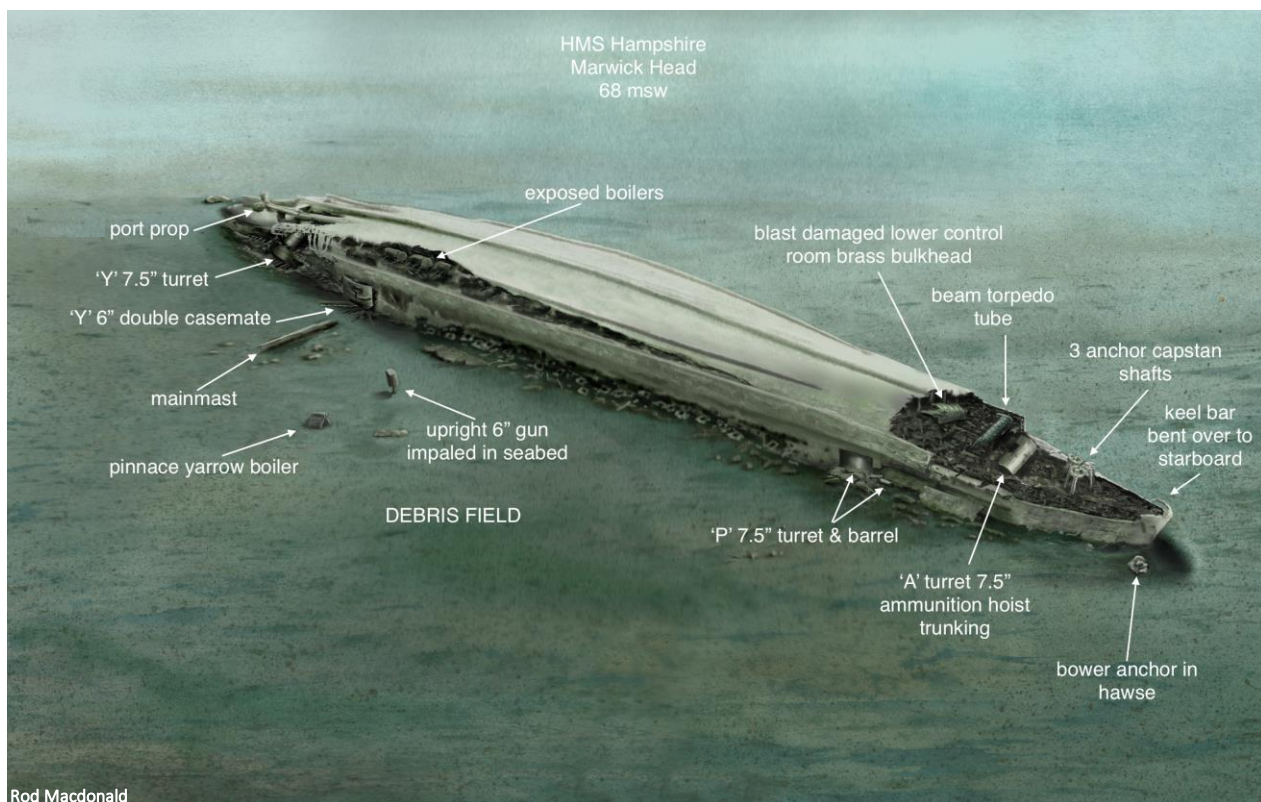


Figure 31: Artist's impression of HMS HAMPSHIRE

11.1 Site Description Overview

- Today the wreck of HMS HAMPSHIRE lies at Lat 59° 07.065' N and Long 03° 23.843' W, about 1.5 nautical miles west of the sheer cliffs of Marwick Head. The Kitchener Memorial rises prominently from the nearest land point to the east.
- The wreck lies almost completely upside down on a bearing of 310° with her bows to the north west and her stern to the south east.
- There is a maximum seabed depth of 68 metres of water in a depression at her bow.
- The general depth to the seabed is approximately 66 metres, depending on the state of tide.
- The wreck has a least depth over her of approximately 55 metres.
- The seabed around the wreck is largely sand and hard shale with scattered large Norwegian glacial melt boulders, some several metres high. There is no silt and the wreck is clean, uncovered by sand and largely unobstructed.

11.2 Site Description – Detail

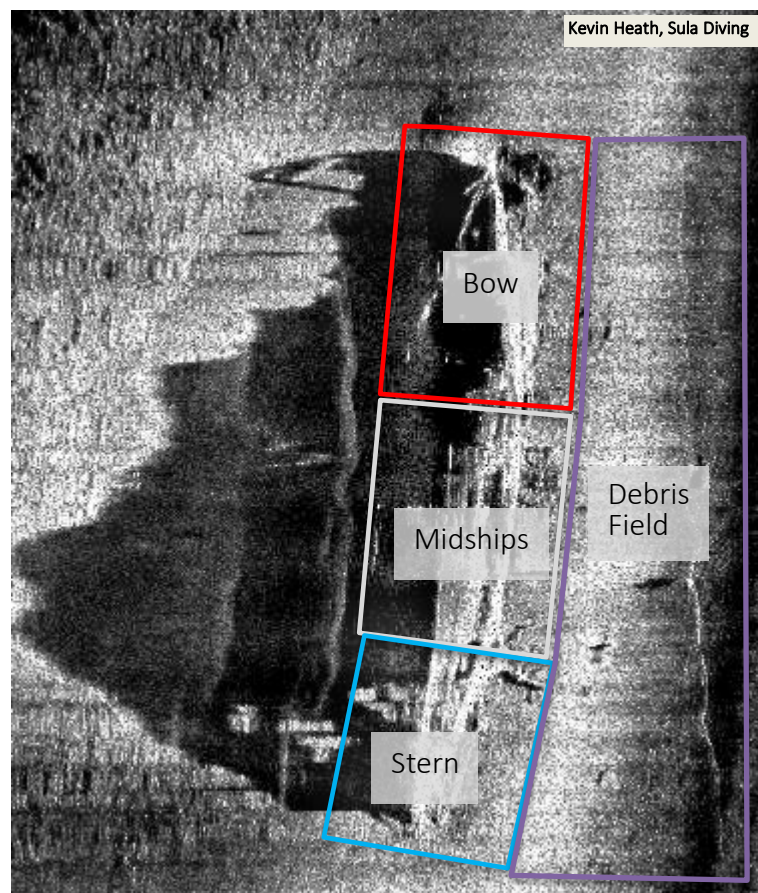
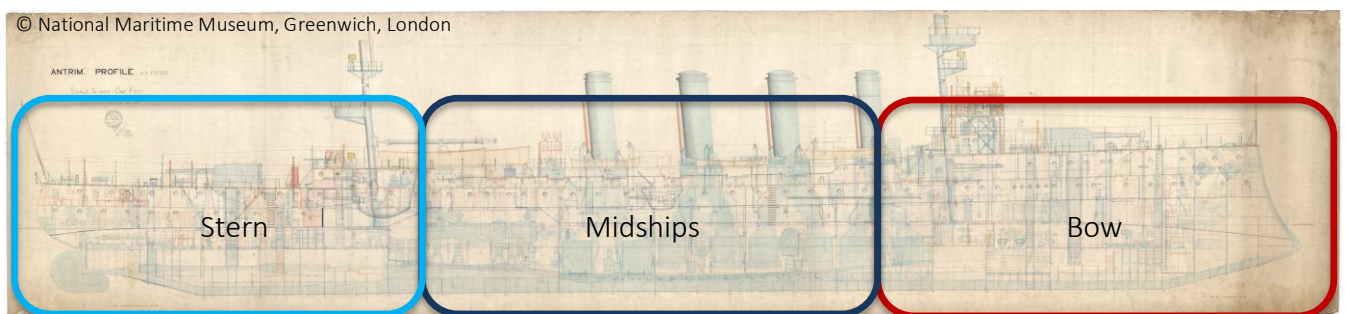


Figure 32: For the purpose of a detailed site description the wreck site has been divided into four sections: Bow, Midships and Stern and Debris Field as shown above and below



11.3 The Bow Section

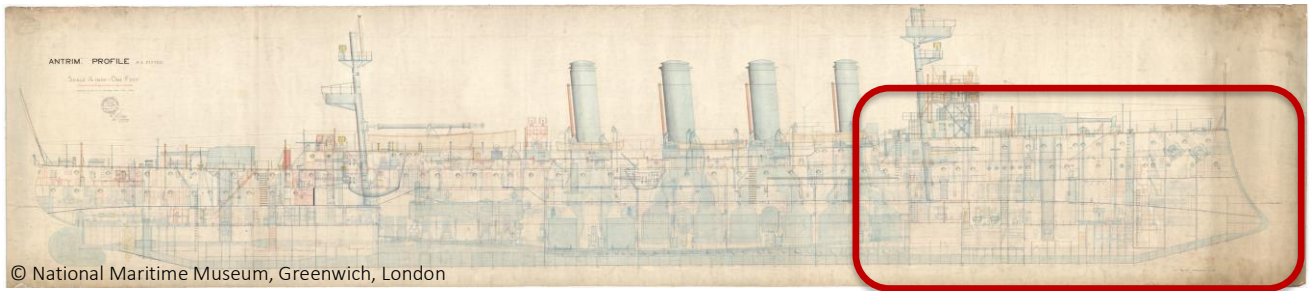


Figure 33: The Bow Section

The stem is intact from the top of the tapered vertical armoured belt to the keel and stands approximately 7.5 metres to the highest point. There is no evidence of damage to the remaining stem. The Boat Deck and the Upper Deck forward of P-turret have been crushed so that the upturned bow now rests on the top edge of the main vertical armoured belt. The forward compartments above the main vertical armour belt were lightly protected and held crew spaces on two deck levels. Scuttles (portholes) were housed in the Boat Deck and Upper Deck and are visible in Figure 35.

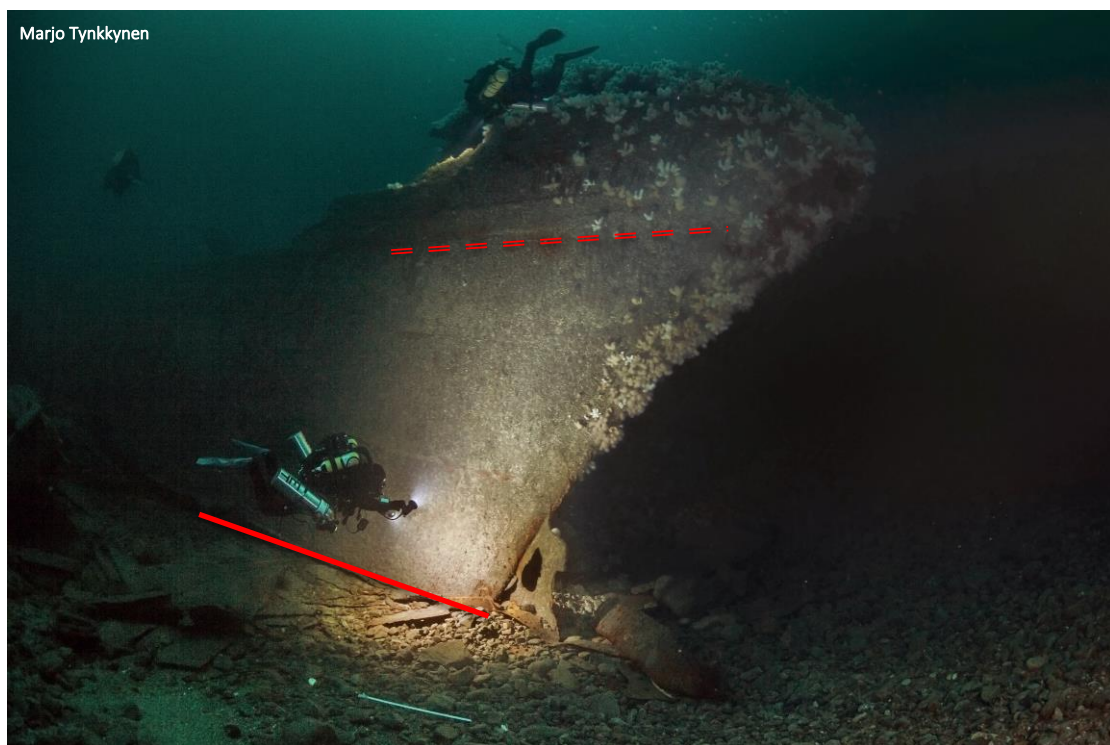


Figure 34: The intact stem – to right of shot. Damage to her keel can be seen top left

In Figure 34, the lower single red line delineates the top of the vertical armour belt. The top dashed red lines delineate the bottom of the armour belt. The two deck levels formerly above the belt have been crushed.

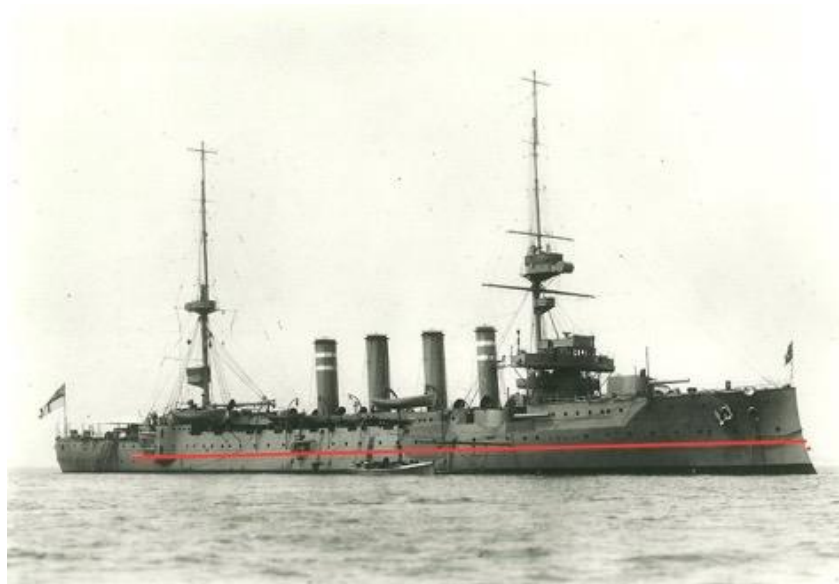
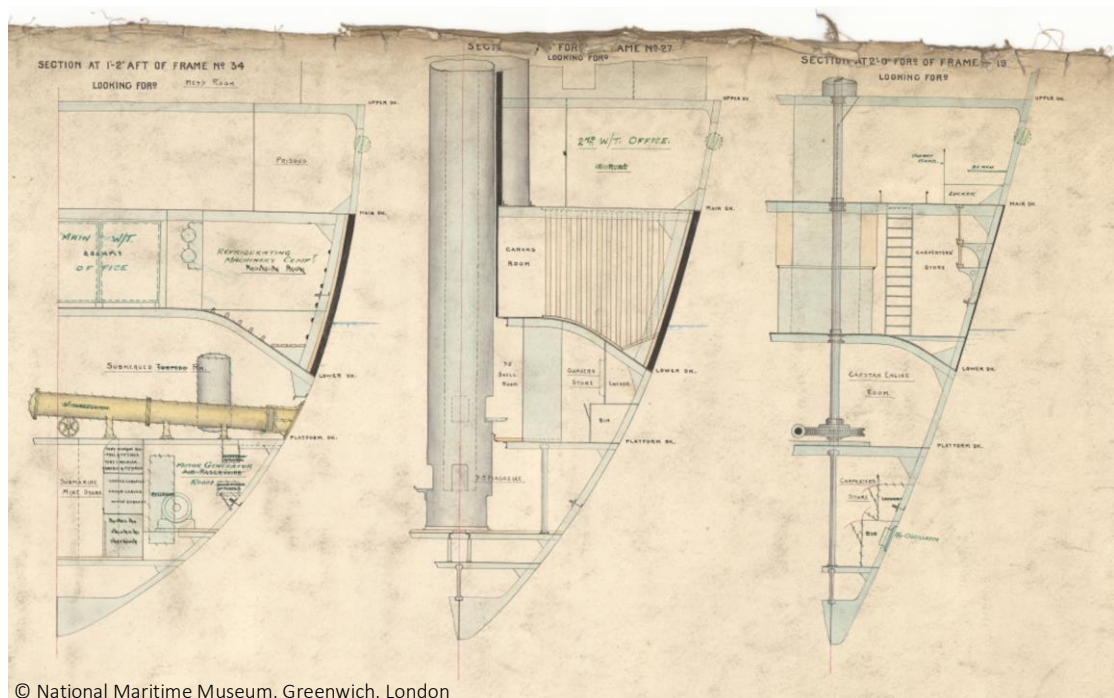


Figure 35: The red line delineates the top of the waterline main armour belt



© National Maritime Museum, Greenwich, London

Figure 36: Bow cross sections showing armour belt, broadside torpedo tube, A-turret ammunition hoist and anchor capstan drive shaft

The main vertical armour belt was constructed of two rows of plates butted together top and bottom and fore and aft. The surviving plates show smooth joins. No evidence of tongue and groove locating joints were found during the survey. Armour plates were mounted over a teak timber backing and bolted through the normal hull plating.

Below the armour belt, the keel of the ship was unarmoured steel shell plating. Aft of the stem there is a large area of damage to the lower hull structure stretching back to frame No 38, just forward of the Bridge. The hull plating is absent in the most part down to the armour belt where teak backing and armour plate bolts are exposed. On both sides of the stem, small sections of shell plating are still present. There is very little shell plating left in situ on the port side, but longer higher sections of shell plating are present on the starboard side. This is in contrast to further aft in this area where only the side armour plates are left with no visible signs of hull plating.



Figure 37: Looking forwards to the upturned stem



Figure 38: Warps of cable and debris

Looking forward towards the upturned stem (Figure 37), fragments of hull plating can be seen on the starboard (left) side of the ship, whilst on the port side (right) the remaining shell plating quickly reduces in height to meet the thicker tapered vertical armour belt plates.

The internal deck is still present but sags downwards. Warps of cable and associated debris fill the space (Figure 38).

The remaining fragments of hull plating on the starboard side end just forward of the three

forward anchor capstan drive shafts and lower gearing. These project upwards and are canted over to starboard, undamaged by any blast effects. Aft of the capstan drive shafts, only vertical main armour belt plates remain, with a distinct lack of hull plating until the main hull reforms at frame No 38.

The vertical armour belt plates themselves remain largely undamaged along both sides of the bow. These all appear to be intact except for:

- One section of armour belt plate on the starboard side has been displaced and now rests on the seabed above a possible torpedo body.

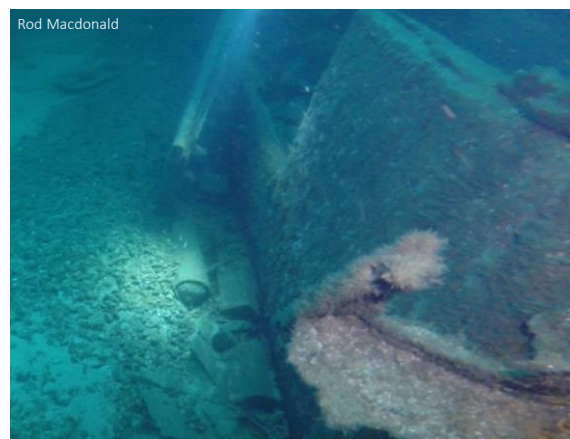


Figure 39: Armour belt

- On the port side adjacent to A-turret plates have been displaced. Inside the damaged area at this point the ammunition hoist trunking is intact and still attached to A-turret, although it now leans to starboard.

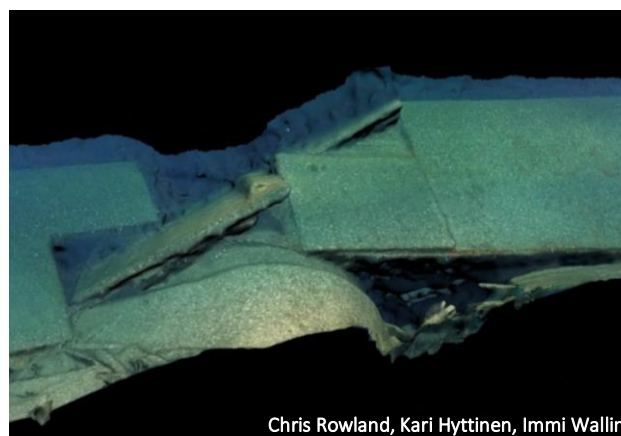


Figure 40: 3D image of port side displaced armour plate near A-turret

- Further aft on the port side just aft of P-turret, armour belt plates are displaced. Moving further aft, hull plating from the Upper Deck becomes visible as the ship is propped up on her port side by the P-turret and the Bridge structure. This thinner plating has buckled and been pushed out to the side.



Figure 41: Armour belt and Upper Deck plating at P-turret

The keel bar has been severed at approximately frame No 28, some 20 metres abaft the stem, and has been smoothly bent over so that it now angles downwards from the stem to where the severed end rests on the seabed to starboard.



Figure 42: Port view of the bow showing keel bent over to starboard



Figure 43: Starboard view of bow showing severed keel

Lying on the seabed surrounding the bow are many pieces of hull plating. The majority of these lie under the broken keel on the starboard side.



Figure 44: Wide angle starboard view of severed keel

Also visible in Figure 44 is the straight edge of the underside of armour belt with some hull plating still in situ adjacent to the bent keel and more lying under the keel. The three anchor capstan drive shafts pushed up through the ship are to the right of the above image.

The three anchor capstan drive shafts are undamaged by any blast effect and are canted over to starboard. The deck capstans themselves are under the wreck, with one visible on the port side. The gears seen in the image below would have been driven by a small steam engine, which is also visible in the debris (not pictured).

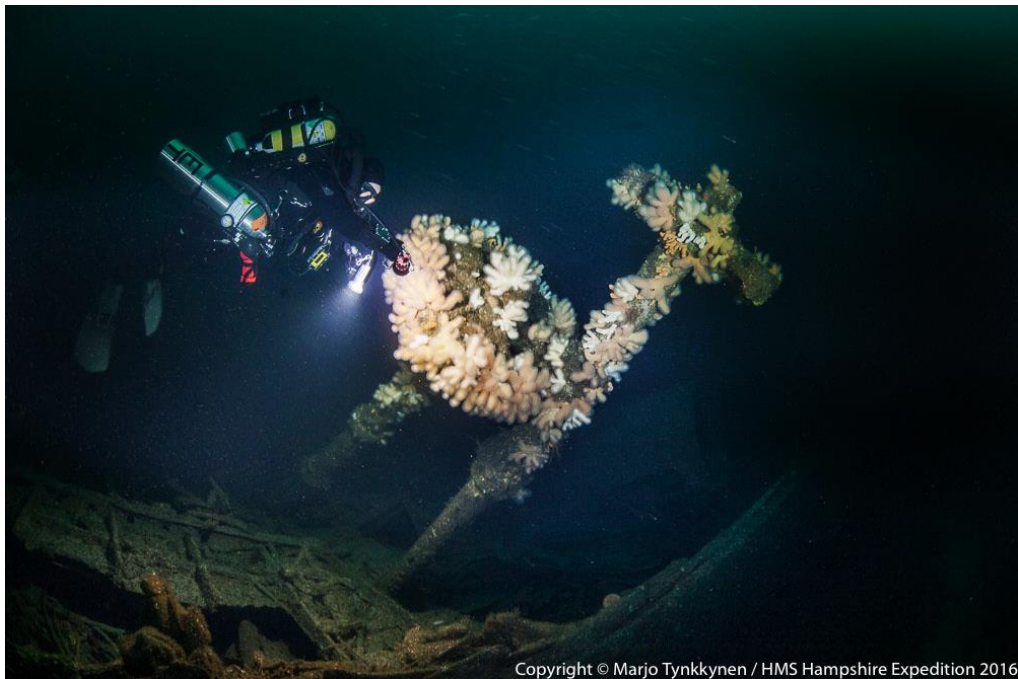


Figure 45: Capstan drive shafts

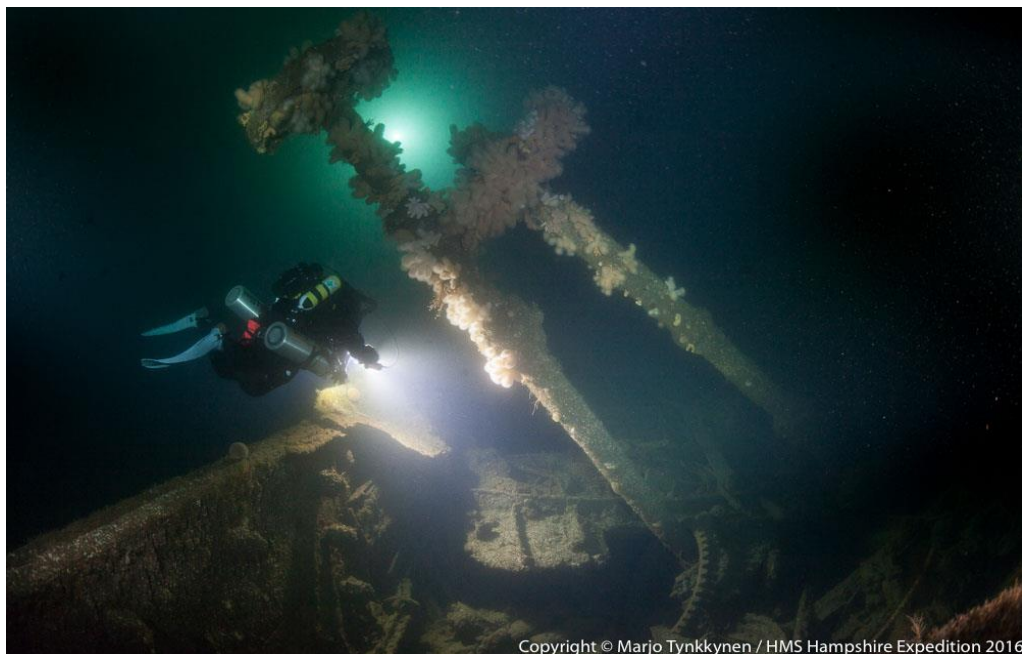


Figure 46: Forward anchor capstan gears and drive shafts protrude up from the bow wreckage

A-turret ammunition hoist trunking lies in the bow debris just aft of the three capstan shafts and leans to starboard. It is still attached to the gun, which is displaced to port and just visible on the seabed. The trunking shows signs of decay consistent with 100 years of submersion in saltwater, but is otherwise undamaged.



Figure 47: Starboard waterline vertical armour belt plates to left of shot, with A-turret ammunition hoist trunking in foreground and capstan drive shafts and gearing beyond



Figure 48: Looking aft on the starboard side at the base of A-turret hoist trunking

HMS HAMPSHIRE's two lateral submerged torpedo tubes were positioned on the Platform Deck between frame Nos 33 and 37. The starboard torpedo tube lies in the damaged area of the bow in the approximate correct longitudinal position, although it now rests lower in the wreckage. The tube appears complete and undamaged with the inner torpedo door attached. On the seabed the outer door is visible in severed hull plating to starboard. The port side tube was not located during the survey. The port side tube outer door, however, remains in situ in the port hull plating. Intact torpedo warheads lie in the bow wreckage adjacent to the tube and a possible torpedo body lies outside the wreck, flush with the starboard side of the hull.



Figure 49: Looking forward towards the bow, the starboard torpedo tube can be seen in the debris

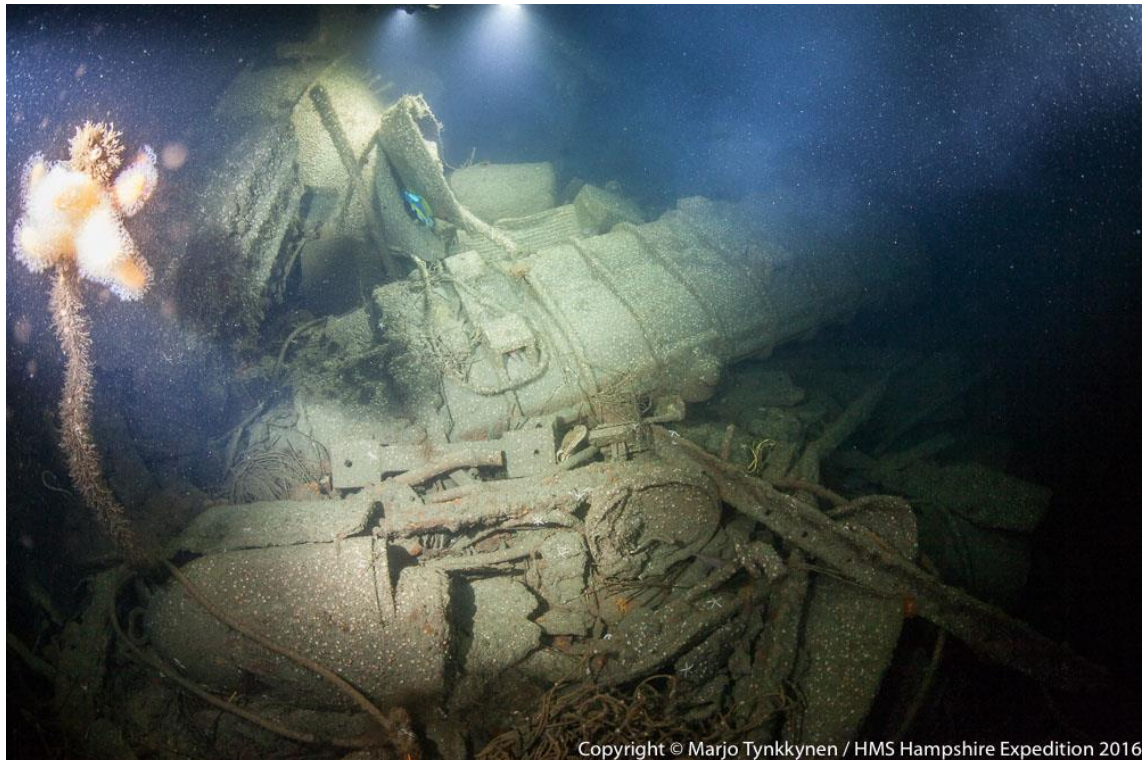
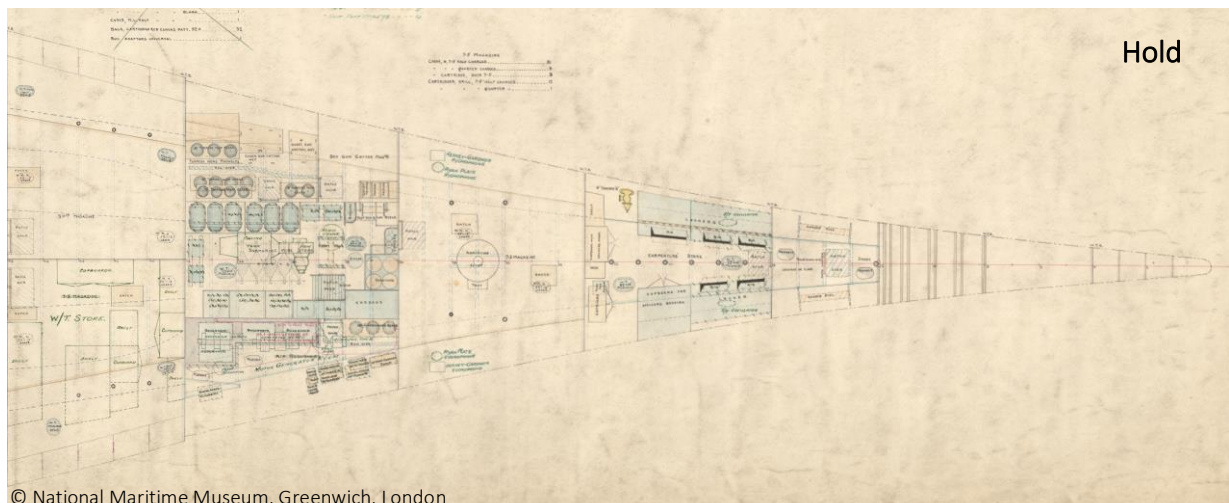


Figure 50: The starboard torpedo tube seen from forward

11.3.1 Forward Munitions

Plans of the Hold and Platform Decks show magazine, projectile and mine storage in the bow section.



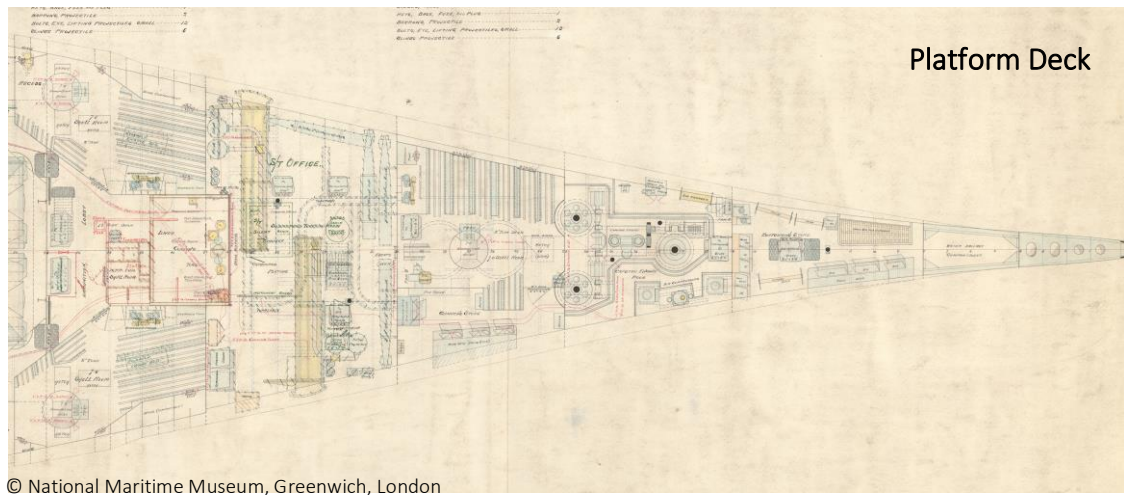


Figure 51: Two plans of the Hold and Platform Decks show magazine, projectile and mine storage in the bow section

All of the munitions for the A, P & Q-turrets, the forward 3-pdr guns, the 12-pdr guns and the torpedo magazines were located in the bow of HMS HAMPSHIRE across the Hold and Platform Decks in the area that is now exposed on the wreck. This would have extended to several hundreds of cases of propellant cartridges and projectiles. Large numbers of these are exposed and visible both inside the damaged bow area and on the seabed to port. A possible single torpedo tube body is visible on the starboard side seabed.

The forward torpedo rooms were surrounded fore and aft by 7.5-inch propellant magazines and shell rooms. The Hold and Platform Decks have collapsed on top of each other down to the armoured Lower Deck, which rest at the bottom of the damaged bow area. Debris from the hull, magazines, shell rooms, torpedo rooms and other compartments now lie amongst the wreckage in this area roughly in their correct relative positions when compared with the plans. Torpedo warheads and sea mines are present along with cordite and cartridge storage boxes and shells. These all appear to be visibly intact, although there is evidence of hydrostatic pressure damage to many of the cordite boxes. The survey found no evidence of explosive damage to the cordite boxes or evidence of mass explosion to any of the other munitions.



Figure 52: 7.5-inch shells from the remains of P-turret shell room



Figure 53: Cordite in ribbed brass flash-proof storage boxes lie in the bow wreckage adjacent to internal timber support for the armoured belt. Note the large stud nut in bottom right

Close to A-turret hoist trunking, 7.5-inch cordite can be found in ribbed brass flash-proof storage boxes from the propellant magazine. Internal timber support strips for the armour belt (to right of Figure 53, above) designed to cushion the shock of large calibre hits on the

armour belt to protect the inner ship are also visible. A large stud nut (to bottom right of image) secures the bolt that goes through the inner ship's side and is tapped into the back of the armour belt plating.



Figure 54: 7.5-inch flash-proof ribbed brass cordite storage boxes in vicinity of P & Q-turret magazine



Ribbed brass boxes of cordite propellant in the exposed magazine for P & Q-turrets are being exposed by the collapse of the hull on the starboard side just as the hull reforms its shape at frame No 38 abaft the bow damage.



Figure 55: Box of 12 per QF brass cartridge cases containing cordite

On the seabed to port a box of base fuzed armour piercing (AP) shells lies amongst debris from the Bridge structure. The top row of shells show protective covers for the ignitors, while the ignitors on the lower row appear to be inserted in the opposite direction, showing a possible waxed paper closure.



Figure 56: A brass torpedo warhead casing showing hydrostatic pressure damage (The degree of damage suggests the warhead is not loaded with explosive and might be for drill or practice)

11.3.2 The Lower Conning Tower



Figure 57: Plans of Lower Conning Tower

The Lower Conning Tower was a secondary control position located below the Bridge on the Platform Deck. It housed all necessary equipment to control the ship, including steering helm, compasses and telegraphs. To aid in reducing magnetic interference the walls of the room were made of brass with a solid brass transverse bulkhead forwards. This entire bulkhead is located at frame No 37 and lies athwartships in the bow area debris just forward from where the hull begins to resume its original shape at frame No 38. The bulkhead is uniformly curved inwards aft, consistent with the effects of a powerful explosion close by.

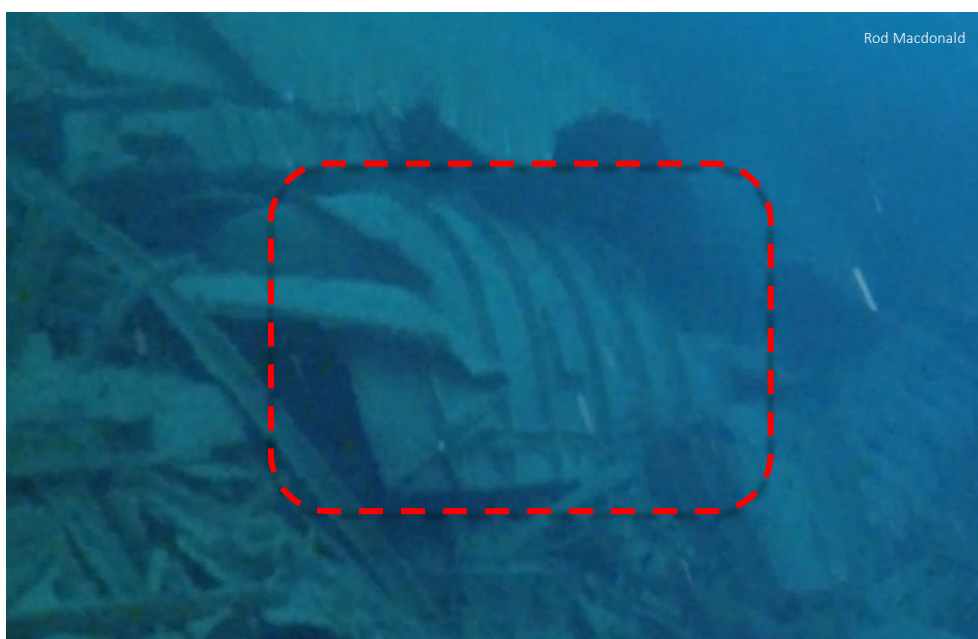


Figure 58: Buckled transverse bulkhead



Figure 59: Lower Control Room brass transverse bulkhead looking forwards

11.3.3 Other Bow Artefacts

Lying on the seabed a few metres away from her stem is a small nonferrous artefact (likely bronze) some 7 – 7.5 inches across. This is believed to be a decorative tampion cover for one of her main 7.5-inch gun barrels. The artefact's location makes it highly likely that it is from A-turret. The historic emblem of the county of Hampshire, a rose surrounded by a crown of leaves, can still be clearly seen. There are 4 screw holes in the face of the tampion plate where the plate was affixed to a wooden tampion body that fitted in the end of the barrel.



Figure 60: Forward 7.5-inch tampion plate lying on the seabed near the bow.

11.3.4 Bow Section Washing Facilities

HMS HAMPSHIRE followed the traditional layout for ship's accommodation with the seamen's accommodation up forwards and the officers' accommodation further aft. The Upper Deck housed the seamen's washing facilities. On the port side adjacent to A-turret was the sick bay and sick bay washroom and head. This solitary toilet is visible in the bow wreckage and next to it lies an upside-down wash hand basin. It is noteworthy that these are the only artefacts originating from one of the upper decks identified during the survey from within the bow area wreckage.

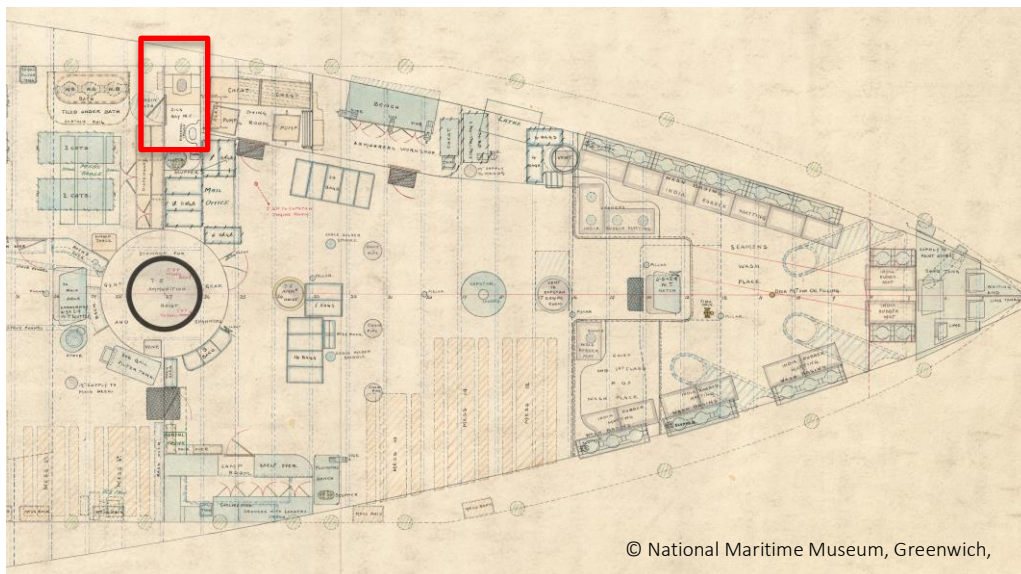


Figure 61: Bow section washing facilities

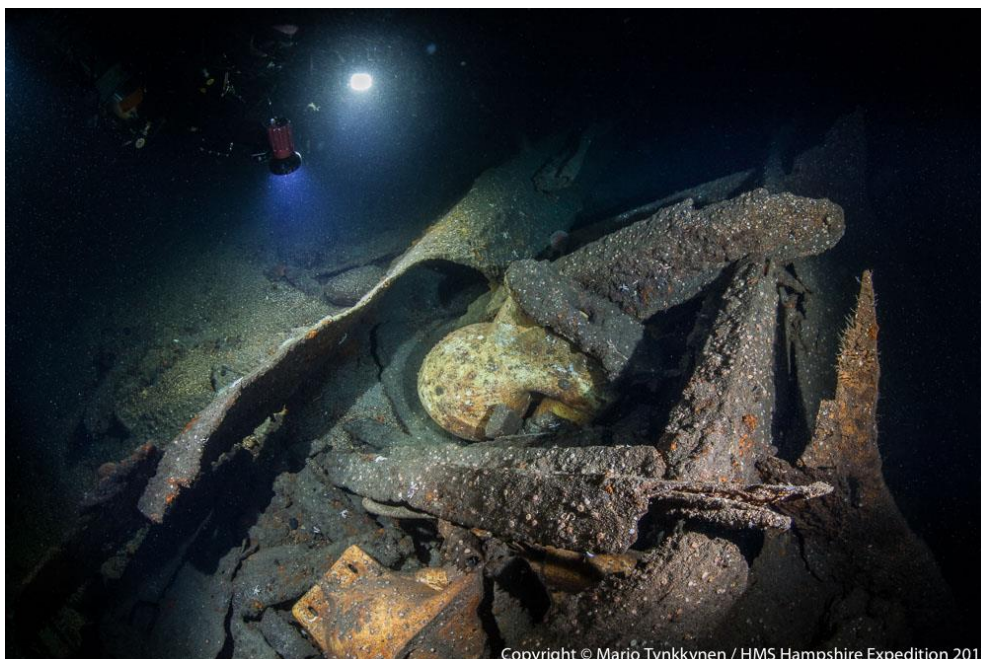


Figure 62: The white toilet and wash hand basin from the sick bay lie upside down in the bow debris

11.3.5 Anchors

HMS HAMPSHIRE, as with many Royal Navy vessels, was fitted with two bower anchors, one on either side of the bow and a third sheet, or emergency anchor, on the starboard side abaft the bower anchor. The port bower anchor lies on the seabed on the port side of the wreck, still secured in its hawse in a detached section of hull plating. The hull plating has been pushed out to port as the ship came to rest upside down on the seabed. Fixed ladder rungs run up the shell plating alongside. There was no sighting of the two starboard anchors, which are presumed to be buried under the wreck.

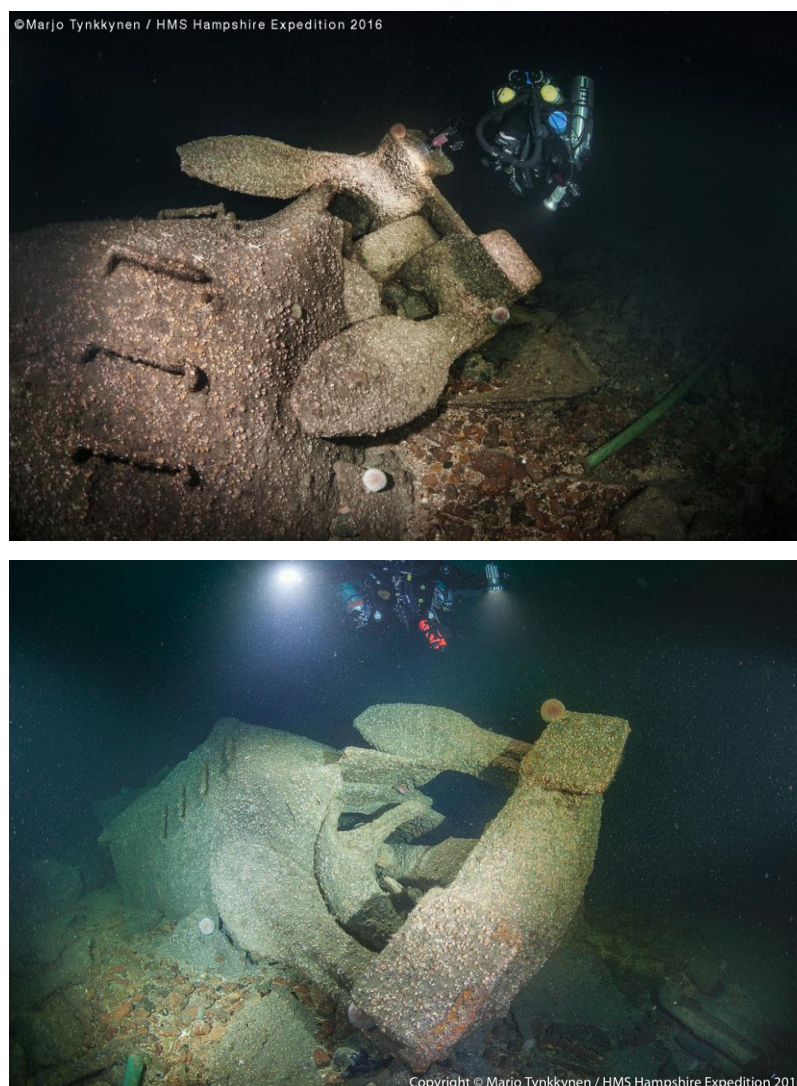


Figure 63: Displaced port side anchor in hawser



Figure 64: Photogrammetry image of anchor

Aft of the anchor on the port side seabed A-turret gun house is visible under the wreckage having been displaced to port during the sinking. P-turret is in situ and clearly visible with the barrel running parallel to the remains of the hull.



Figure 65: The port 7.5-inch P-turret gun barrel abreast the bridge projects from debris

The hull reforms and is largely intact aft of frame No 38 but the leading edge of the athwartships section of hull has sagged downwards. As you move aft on the ship towards the

midships section, two large fissures have opened up in the ship exposing boiler rooms and engine rooms.

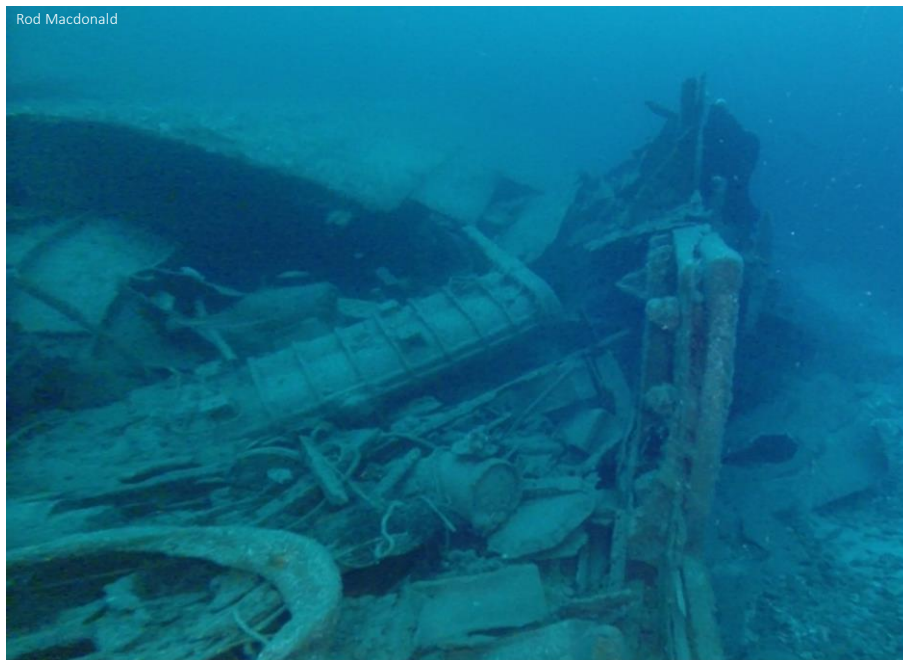


Figure 66: Starboard broadside torpedo tube, located in the bow debris

Looking aft (Figure 66) from the bow along the starboard side of the ship reveals how the keel frames, stringers and shell plating of the bottom of the hull are missing. The keel reforms aft of the ribbed starboard submerged torpedo tube. The starboard ship's side is seen to right of shot with the exterior torpedo tube door lying on the seabed. The large bolts and nuts holding armour plate to the hull are seen on the inside face of the closest starboard plate.

11.4 The Amidships Section

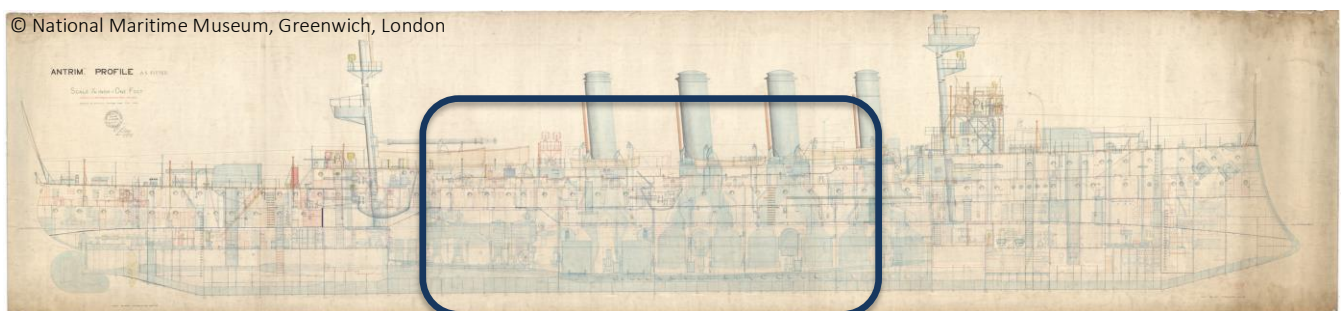


Figure 67: Plan Amidships

The midships section of the wreck lies almost completely upside down propped up slightly on her port side exposing a gap under her upturned deck of up to one metre in height in places. When afloat, unarmoured hull plating ran along either side of the vessel above her vertical main armour belt with a single line of portholes along the amidships section of the ship. (There were two rows of portholes along the hull at the bow.) The unarmoured side hull plates amidships have corroded and fallen away from the ship to the seabed where many of the portholes can still be seen.

It is noteworthy to add that prior to the wreck's closure in 2002, members of the survey team had dived the site in 1997 and 2000 respectively. Their anecdotal evidence compared with some video footage taken during the same period show that most of this hull plating was still in situ at that time.

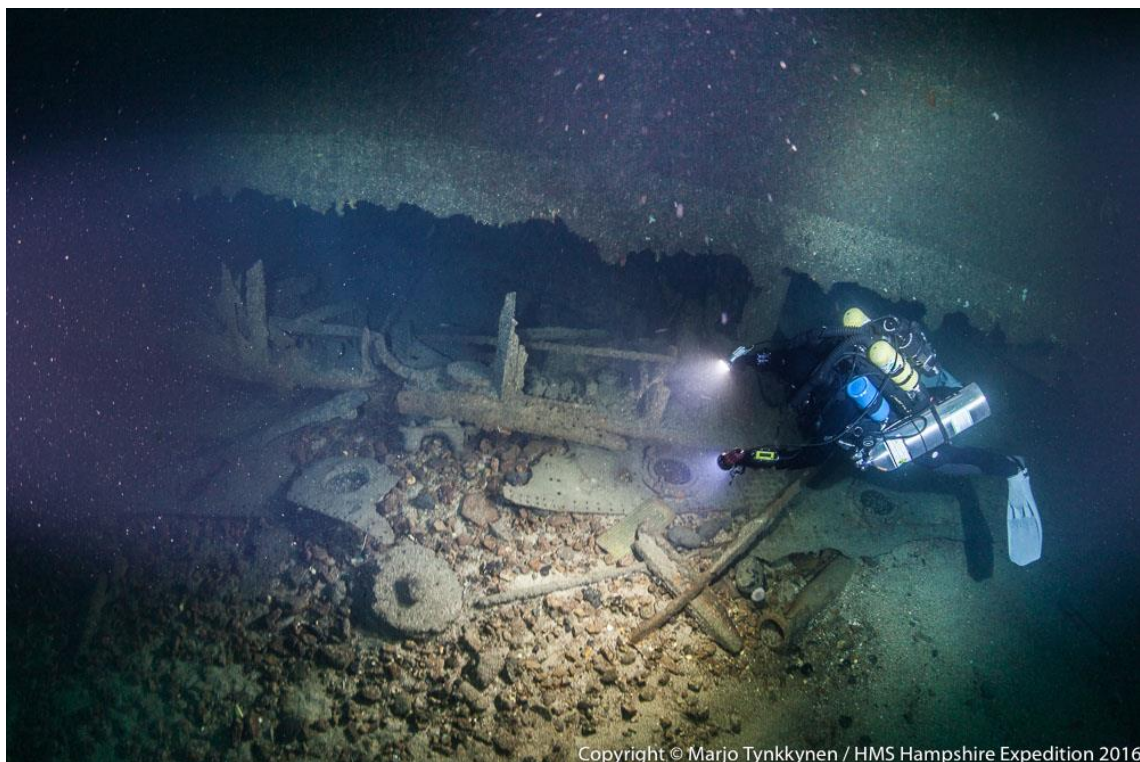


Figure 68: Hull plating has decayed and fallen away from the Main Deck on the starboard side, leaving portholes on the seabed



Figure 69: Starboard side Main Deck porthole, still located in the hull plating, now lies on the seabed with deadlight still open

Artefacts in the Upper Deck which ends just aft of P & Q-turrets and artefacts in the Main Deck have been exposed where the hull plating has fallen away. In addition, deck equipment is visible under the ship where the deck is propped up on the port side.



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Figure 70: Excerpt of the ship's plans showing the port side seamen's heads (toilets), located in the Upper Deck



Figure 71: On the port side, abaft P 7.5-inch gun turret, the forward heads are now exposed

11.4.1 Amidships Guns

Of the two 6-inch guns mounted on the port side of the Upper Deck the aft gun is visible lying parallel to the deck facing aft. Of the five 3-pdr guns mounted on the port side of the ship at the time of her sinking three are still visible in the midships section. All three can be positively identified as Vickers 3-pdr Mk 1 guns and remain on their mounts on the Upper Deck just visible under the ship. One lies just aft of the aftmost 6-inch gun with the second and third forwards of this.



Figure 72: The 4th Mk VII 6-inch gun barrel lies under the wreck

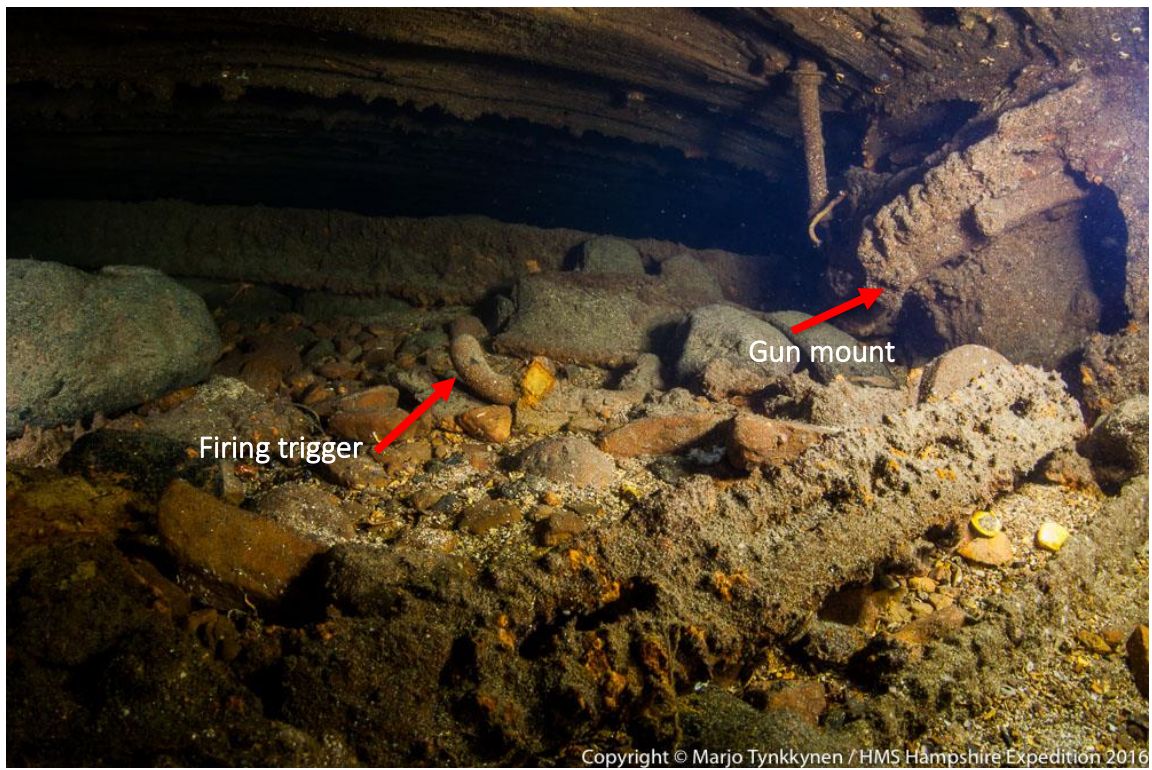


Figure 73: Teak planked deck above. To the right is the gun mount for a Vickers 3-pdr gun

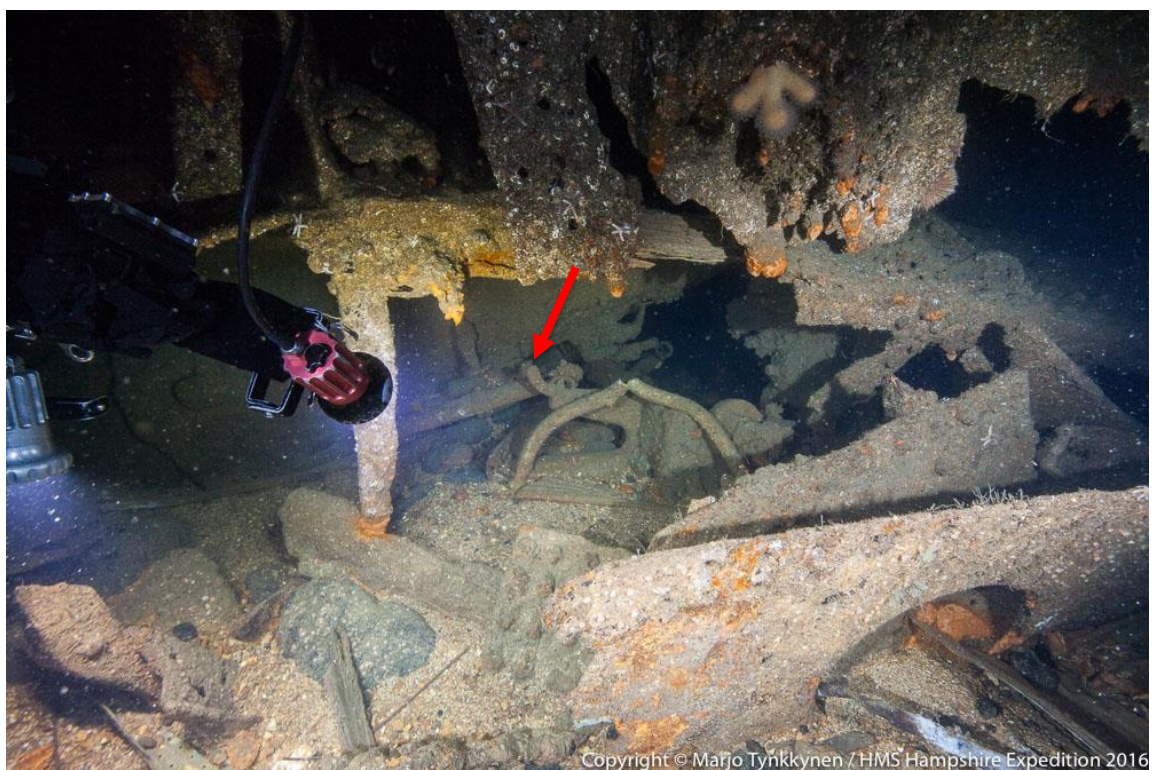


Figure 74: Slightly further forward another upside-down firing trigger can be made out

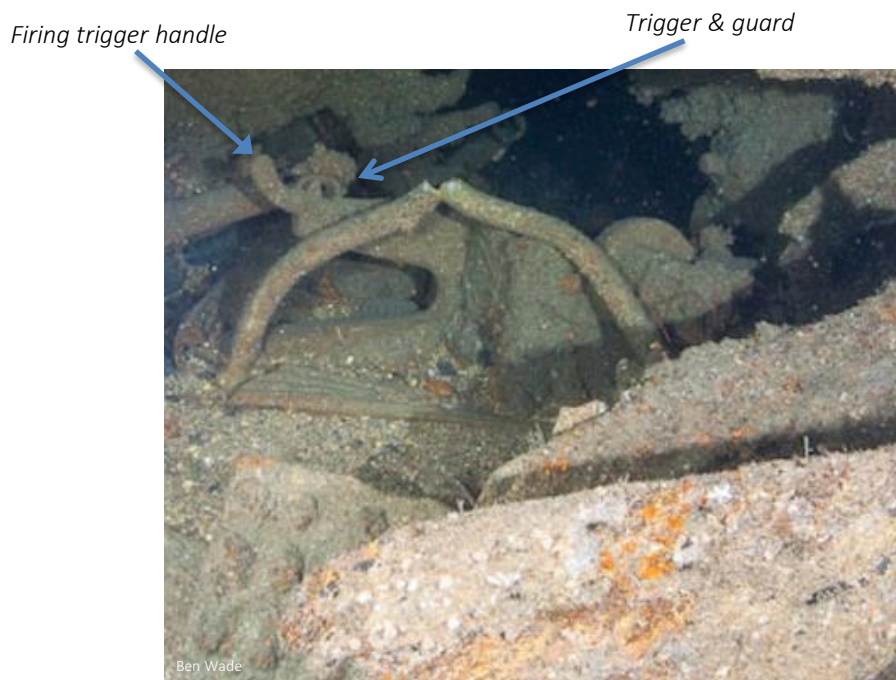


Figure 75: Close up of the firing trigger still on its mount

The redundant and barrel-less midships 6-inch casemate is still visible. It is now just an architectural structure protruding from the port side of the ship at seabed level.

11.4.2 Ship's Pinnace

The remains of a ship's pinnace can be seen on the port side seabed amidships. A steam engine lies near the hull forward of the main mast, and the boom for launching and retrieving the pinnace lies flat on the seabed just forward of the main mast.

11.4.3 Fissures

Above the armoured belt large fissures have opened up on both sides of the wreck, running from the second boiler room at approximately frame No 72 to the stern end of the engine rooms at approximately frame No 150. Exposed in the fissures are the Yarrow and Scotch boilers of the second, third and fourth boiler rooms, the triple expansion steam engines and condensers along with evaporators for making fresh water.

Rod Macdonald

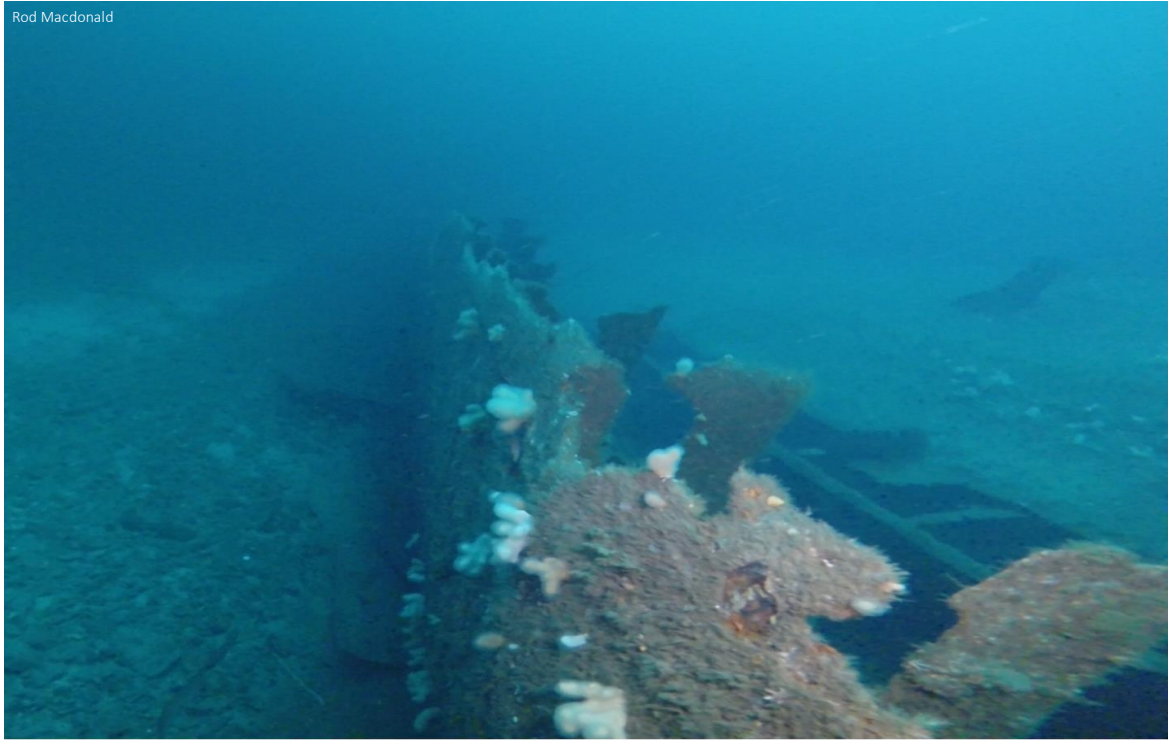


Figure 76: Looking forward along starboard side - fissure in the hull

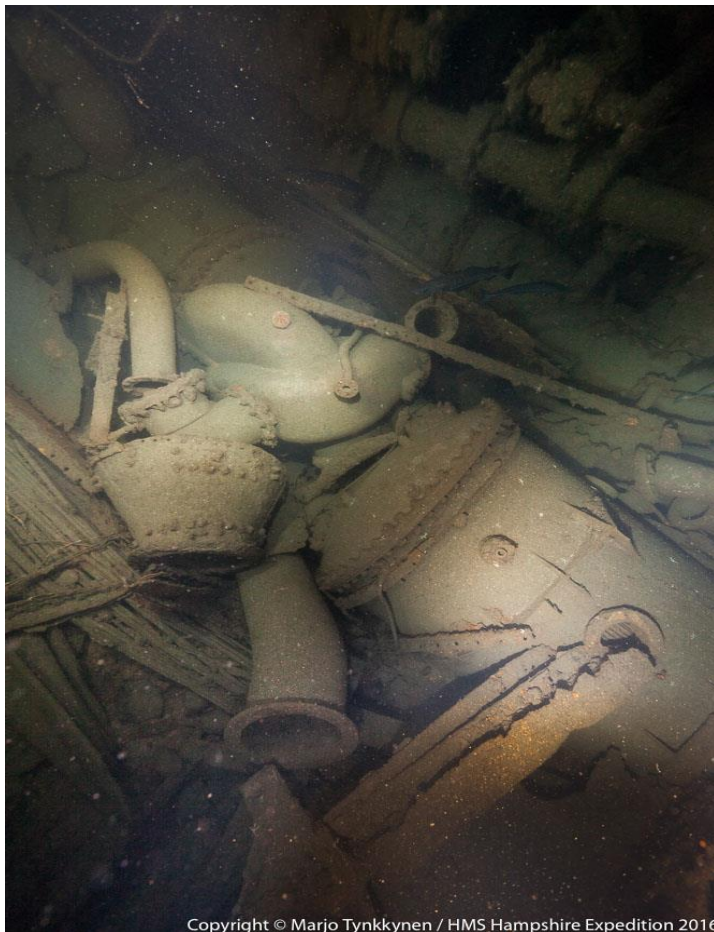


Figure 77: Port side engine room condenser viewed from the top of the port side fissure

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11.4.5 Midships Munitions

A collection of 6-inch shells were located within the fissure at approximately frame No 92 adjacent to where the ammunition hoist would be located to service the centre casemate. An ammunition passage runs the length of both the port and starboard side of the ship on the Platform Deck from frame No 48 at the front of the first boiler rooms to the aft end of the engine rooms at frame No 150. The fissure along each side of the wreck appears to follow this ammunition passage. Examples of both nose-fuzed and base-fuzed shells are present in this area.



Figure 80: Base fuzed 6" AP shells

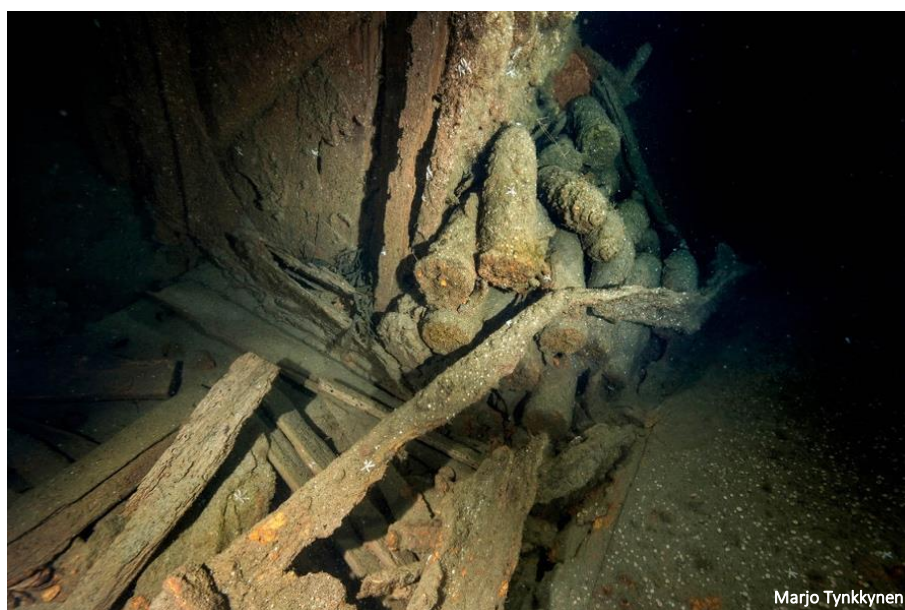


Figure 81: Nose fuzed 6" HE shells

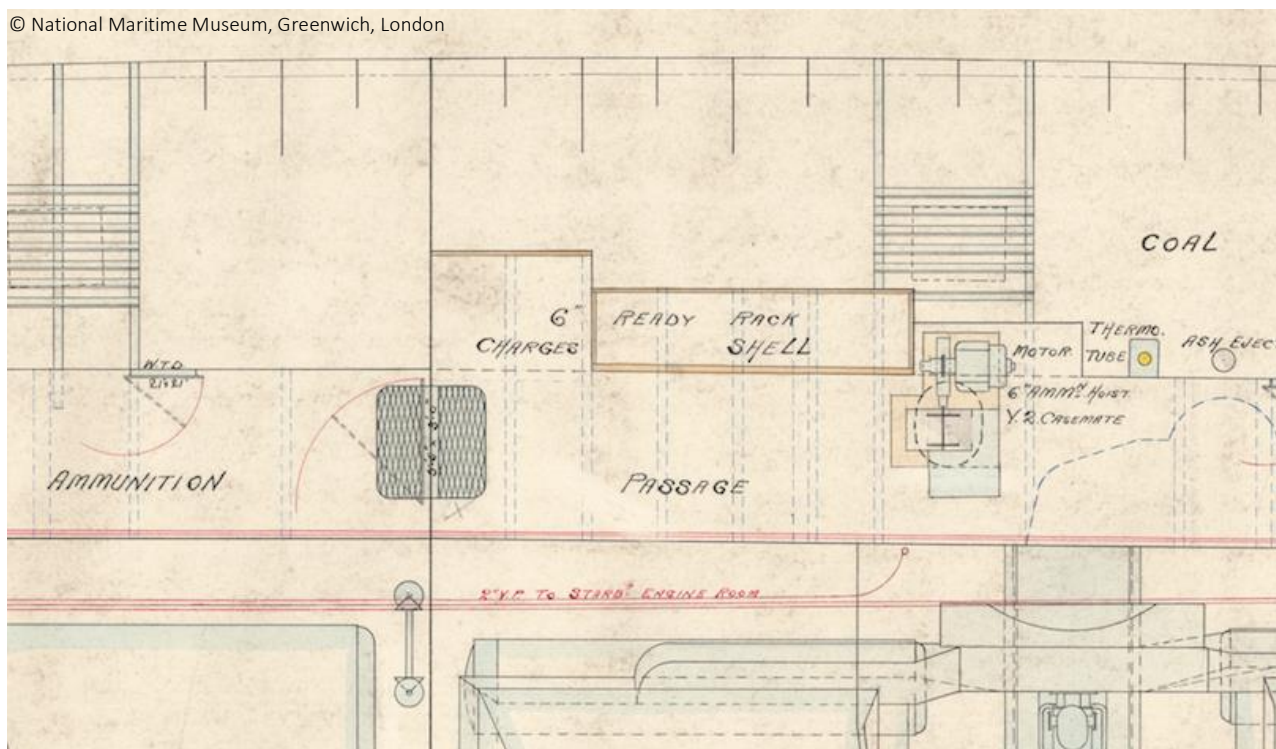


Figure 82: Port side ammunition passage midships showing shell ready rack and ammunition hoist for midships casemate

11.5 The Stern Section

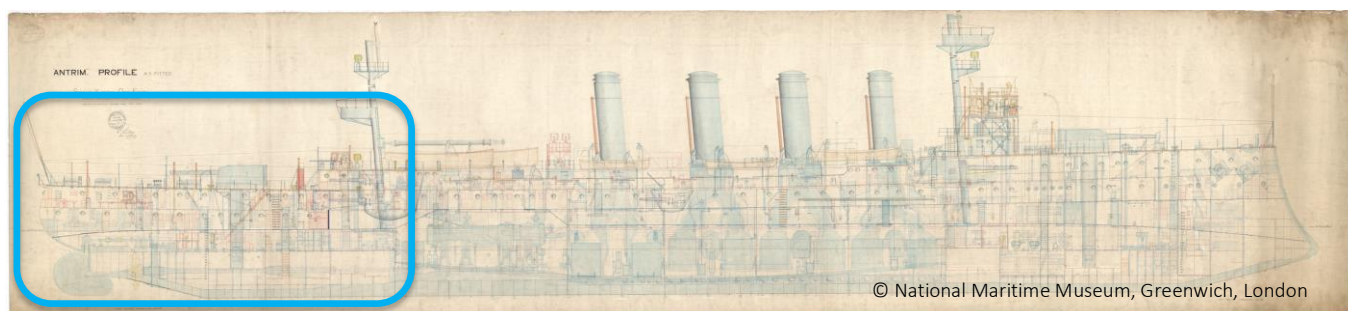


Figure 83: The stern section of HMS HAMPSHIRE as surveyed extends from just forwards of the aft casemate at approximately frame No 145 to the stern encompassing the aft 7.5 inch turret, rudder and her one remaining propeller and shaft

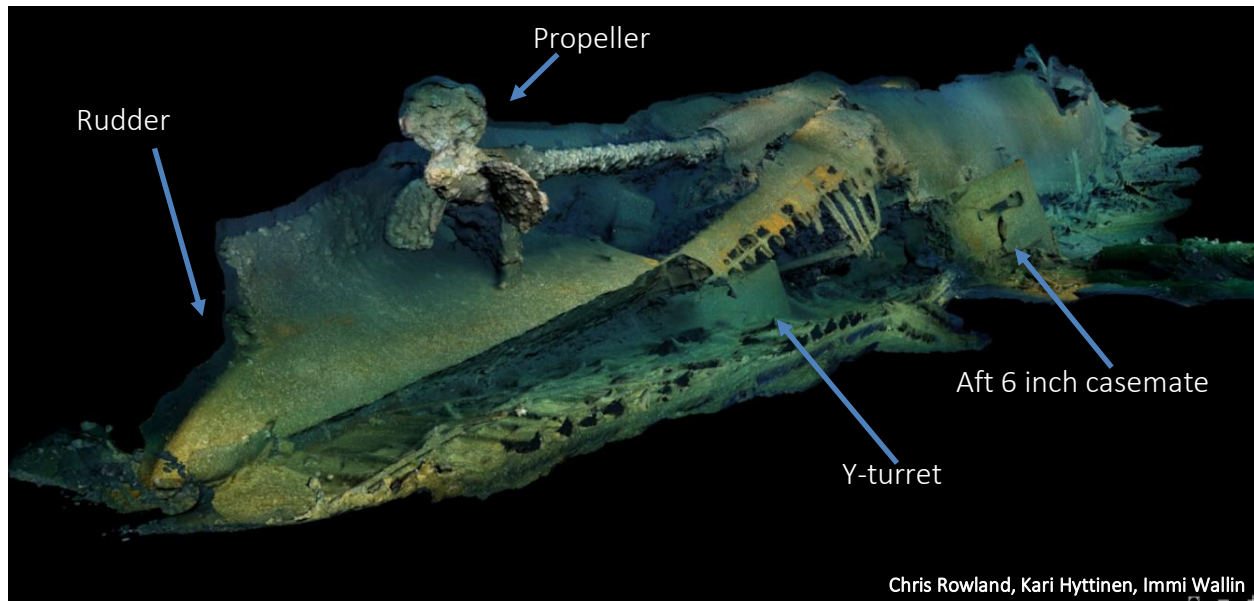


Figure 84: 3D photogrammetry of HMS HAMPSHIRE, port side view

The stern section is propped up on her port side supported by Y-turret. The majority of the hull plating for the Main Deck and the Lower Deck has corroded away from the aft casemate to the stern leaving a substantial gap under the ship. Surviving hull material from this area lies face down on the seabed. Y-turret 7.5-inch gun barrel cannot be seen and appears to be swung to starboard – the direction of capsizing – and is now buried in the seabed under the wreck.

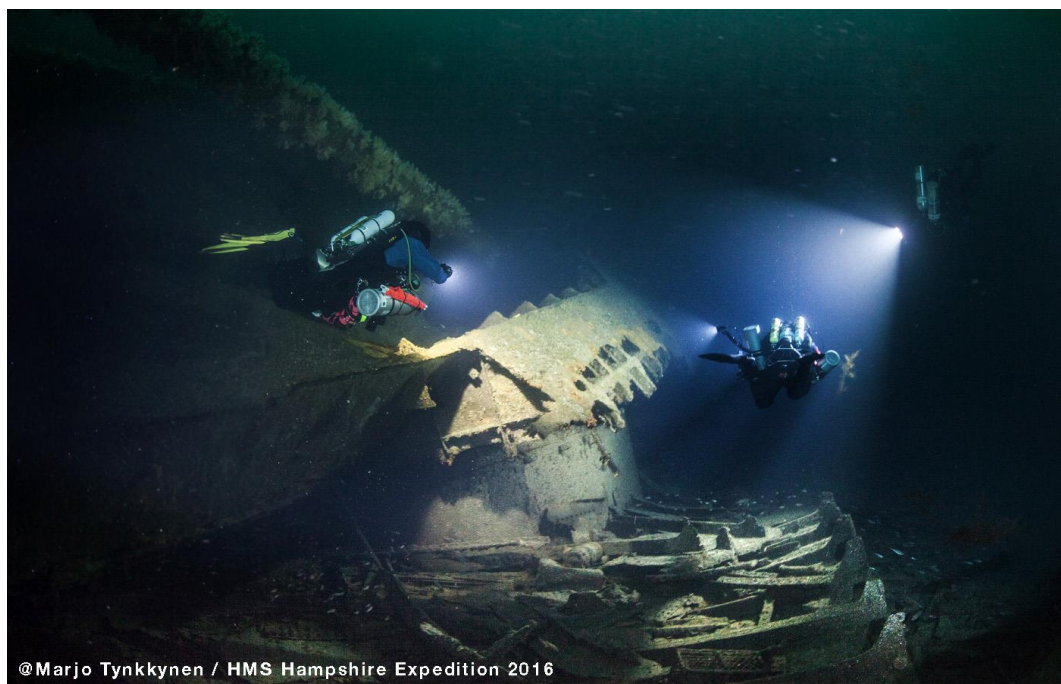


Figure 85: The back of Y-turret gunhouse seen from astern with the free section of the port prop shaft above. The barrel appears to be swung to starboard in the direction of her capsizing

The section of hull directly above Y-turret (as the ship lies today) has largely disappeared, leaving just the keel supported by the ammunition hoist trunking of Y-turret. Clear water is now visible through the side of the ship.



Figure 86: Y-turret ammunition hoist and the port side propeller shaft are visible through the decayed stern

The cylindrical Y-turret 7.5-inch gun ammunition hoist trunking can be seen directly underneath the keel bar - the free section of the port propeller shaft is seen in the foreground above (Figure 86). Either side of the hoist trunking it is possible to see right through the wreck to free water on the other side.



Figure 87: Stern port-side double casemate, as seen here on HMS KENT

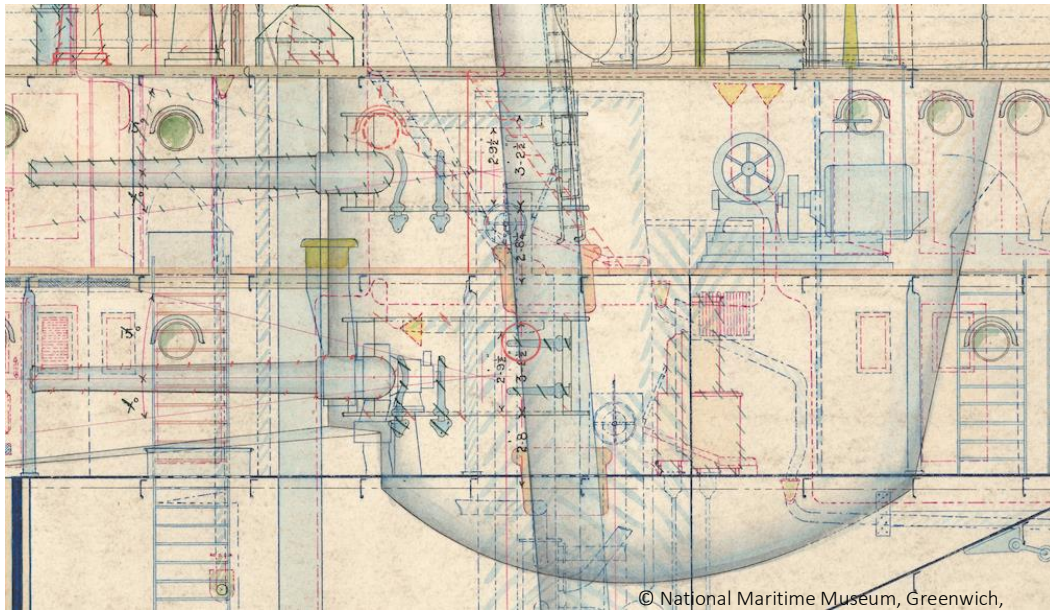


Figure 88: Y1 & Y3 Starboard side Double Casemate as detailed in the ship's plans. The aft two-storey X and Y casemates were situated on either side of the ship abreast the main mast

The lower of each of the two super-firing aftmost 6-inch casemate guns, X3 & Y3, were demounted in 1916 and moved to the Upper Deck in place of demounted 3-pdr QF guns. The lower casemate firing ports were then plated over to improve seakeeping. This plate can still be clearly seen on the port side – the plate has rotted through in the middle.



Figure 89: 3D photogrammetry of Y1 casemate

The aft port side casemate sits in situ and mostly intact except for parts of the casemate armour plate which has become detached from the main hull structure at the forward edge. Parts also lie on the seabed. The higher (now lower) Y1 6-inch gun barrel projects outwards and astern - its barrel lying flat on the seabed.

The barrel of a 3-pdr gun protrudes from the seabed perpendicular to the 6-inch gun barrel. The mount is buried, but it is highly likely to be a Vickers.

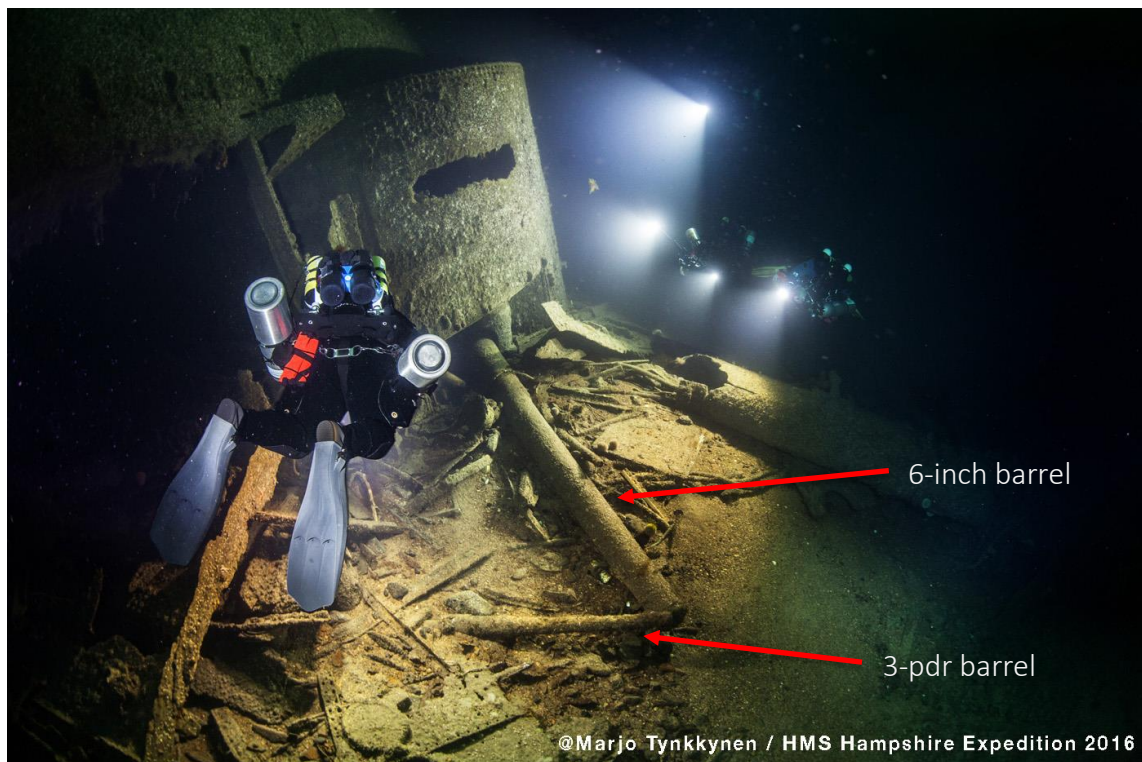


Figure 90: The superfiring Y1 6-inch gun barrel projects from the (now lower) firing port. The plated off lower 6-inch gun Y3 firing port can be seen above – its plate rusted through horizontally. The barrel of a buried QF 3-pdr rises up from the left to meet it

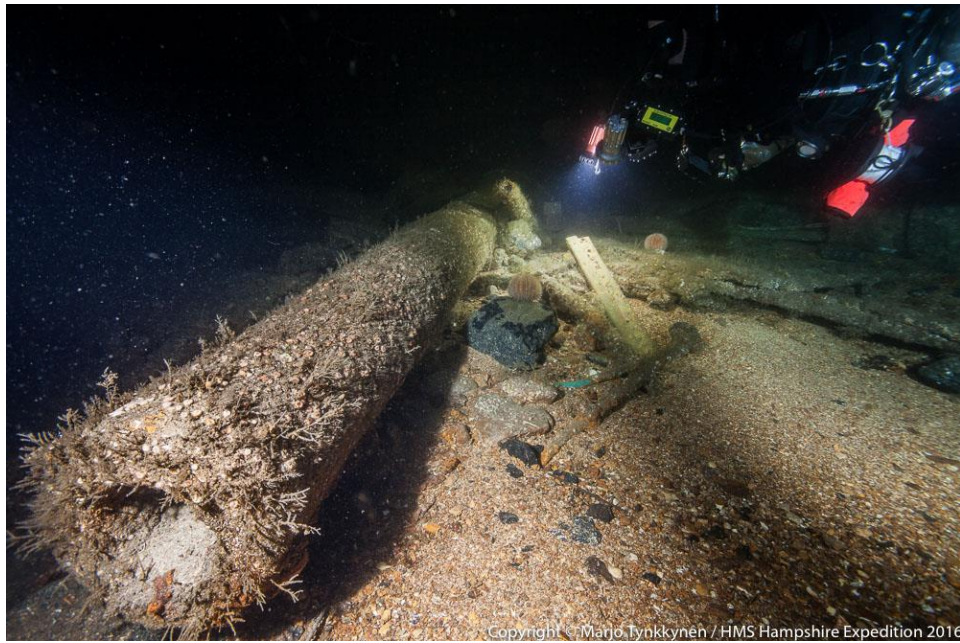


Figure 91: The upper 6-inch Y1 casemate gun barrel lies flat on the seabed pointing aft

11.5.1 Propeller and Shafts

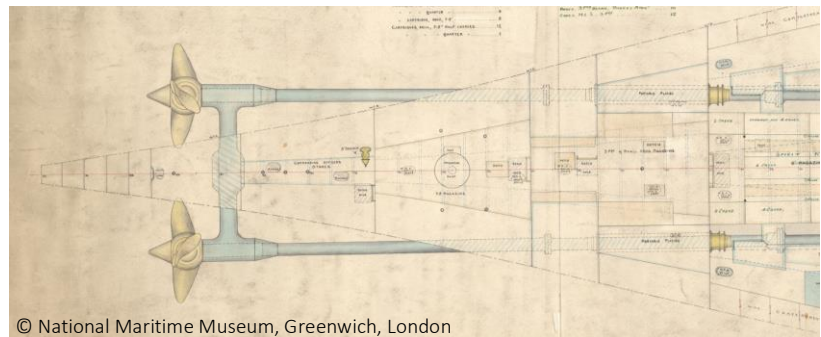
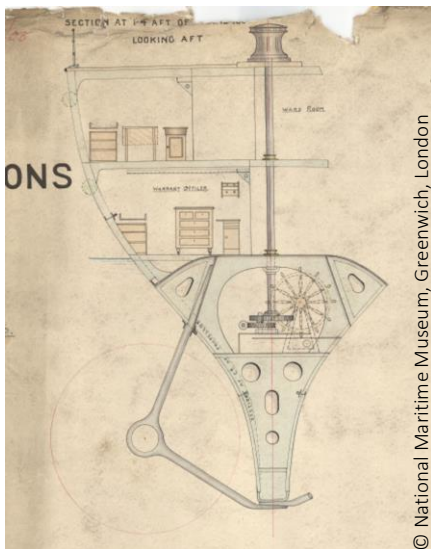


Figure 92: Plans of propeller and shafts

The manganese bronze port propeller, A-frame bracket and shaft are still present on the wreck. The shaft is slightly bent towards the seabed where it exits the ship due to the distortions in the wreck around Y-turret.



Figure 93: Port side propeller

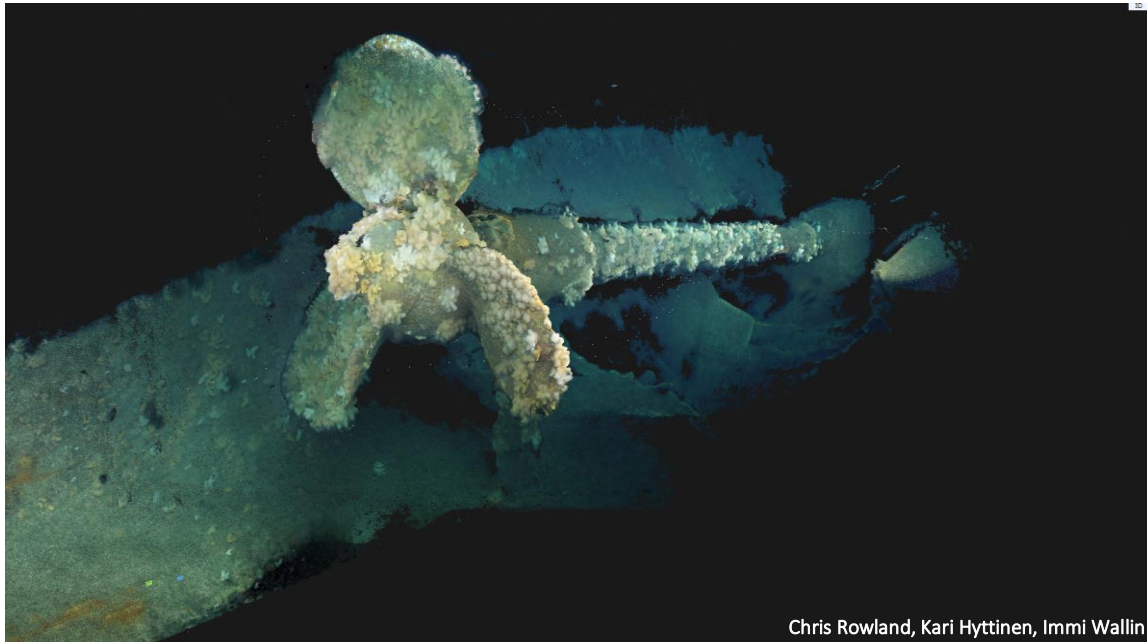


Figure 94: 3D photogrammetry image of the port propeller

The rudder has fallen from its mount to lie flat on the seabed to starboard (Figure 95, below).

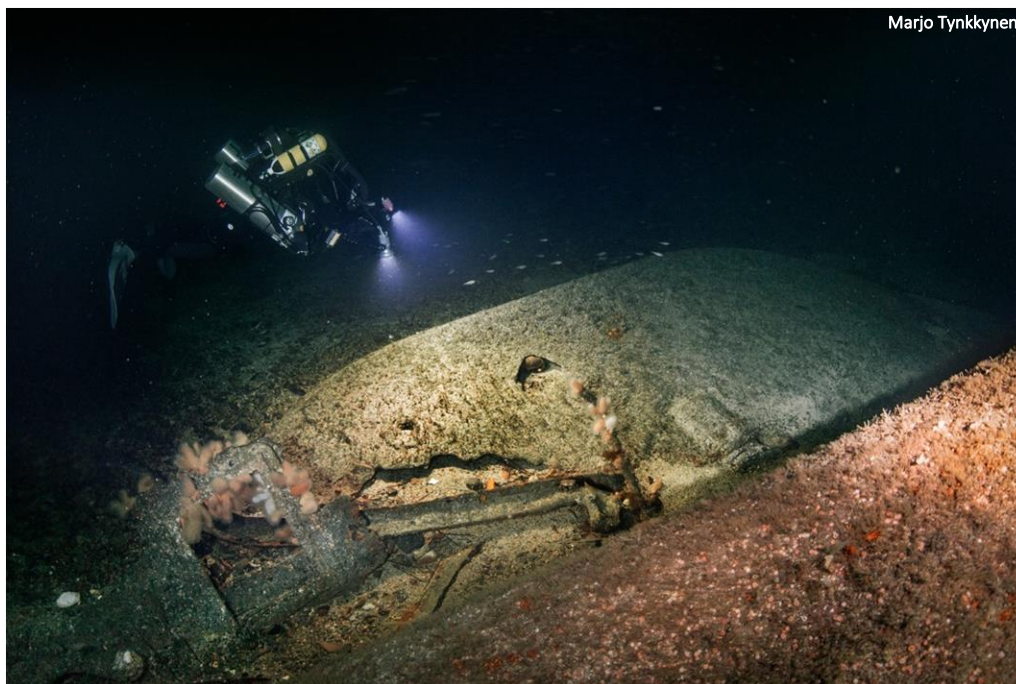


Figure 95: HMS HAMPSHIRE's rudder

The starboard propeller is not present on the wreck. It was recovered in 1983 during a survey and is now on display at the Scapa Flow Visitor Centre & Museum on the island of Hoy. All that remains of the starboard side stern gear is the severed end of the shaft. The starboard shaft emerges from its stern tube in the photograph below (Figure 96) and appears to have snapped at this point.

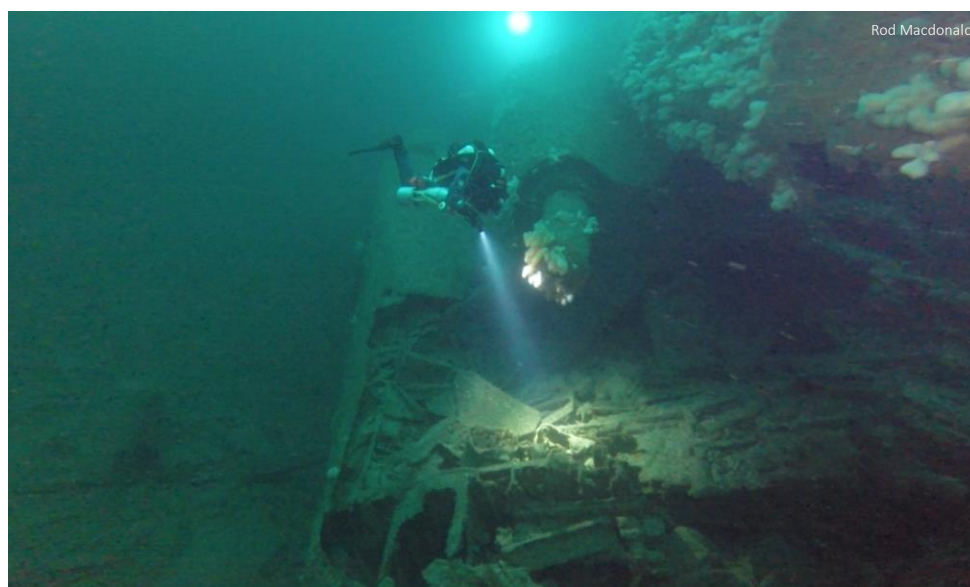
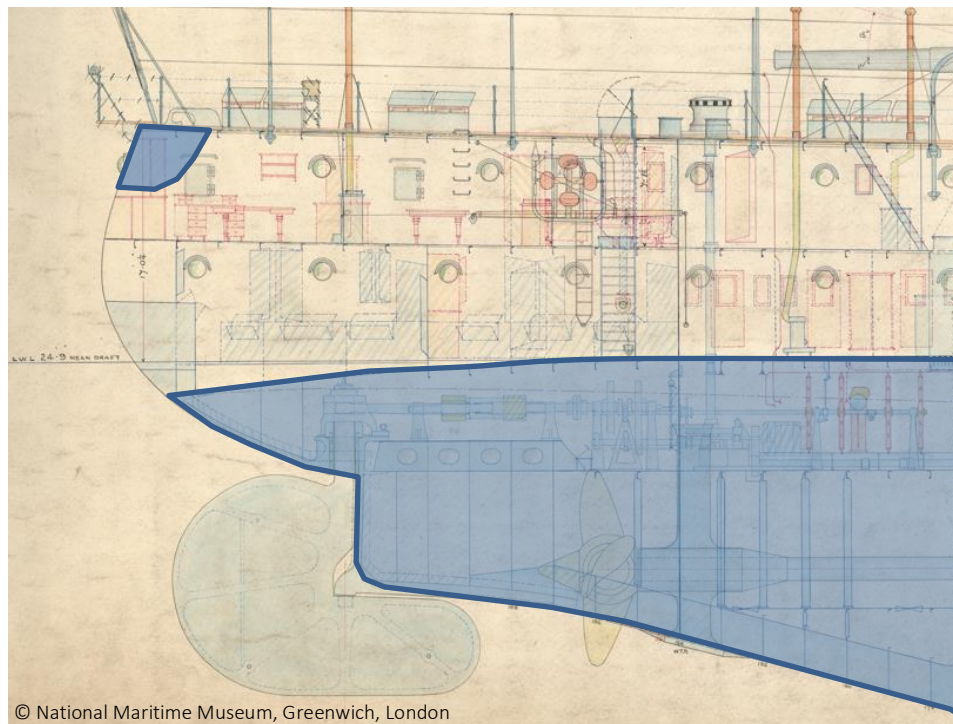


Figure 96: Severed starboard side prop shaft



Of the stern of HMS HAMPSHIRE, the keel to the the Platform Deck remains intact. The aft part of the ship now rests on her armoured deck and the Lower and Main Decks are absent, except for a small part of the Main Deck at the very stern which now sits separated from the main stern wreckage by aproximately two metres. This wreckage contains the sternmost porthole from the Main Deck and the remains of the ship's name. Hull plating from the Lower and Main Decks now rests on the seabed to port and starboard.



Figure 98: The remains of HMS HAMPSHIRE's name can be clearly seen





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Figure 99: The remaining embossed letters of her name 'MPSHIRE can be seen ringing around the remaining section of Main Deck

11.5.2 Stern Munitions

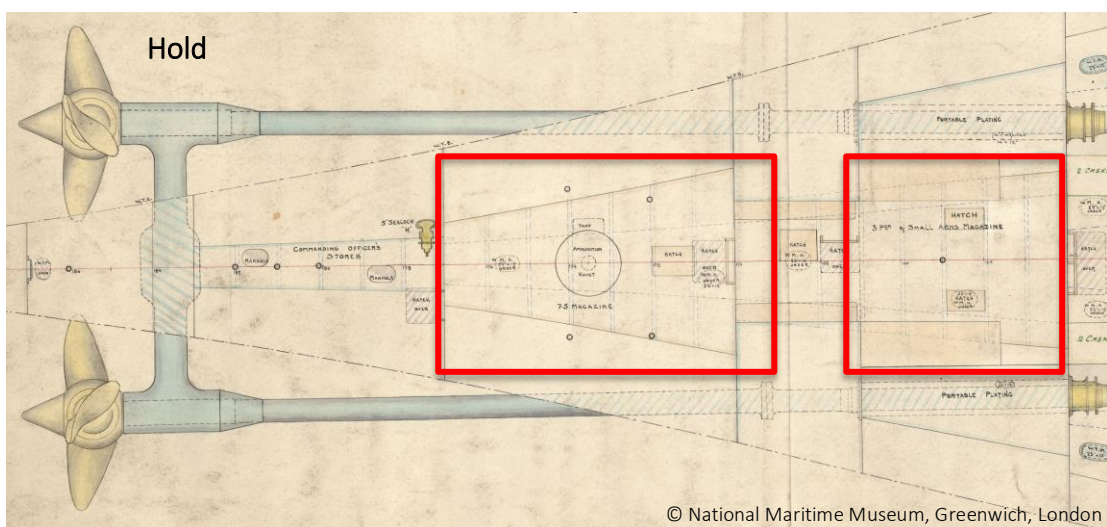
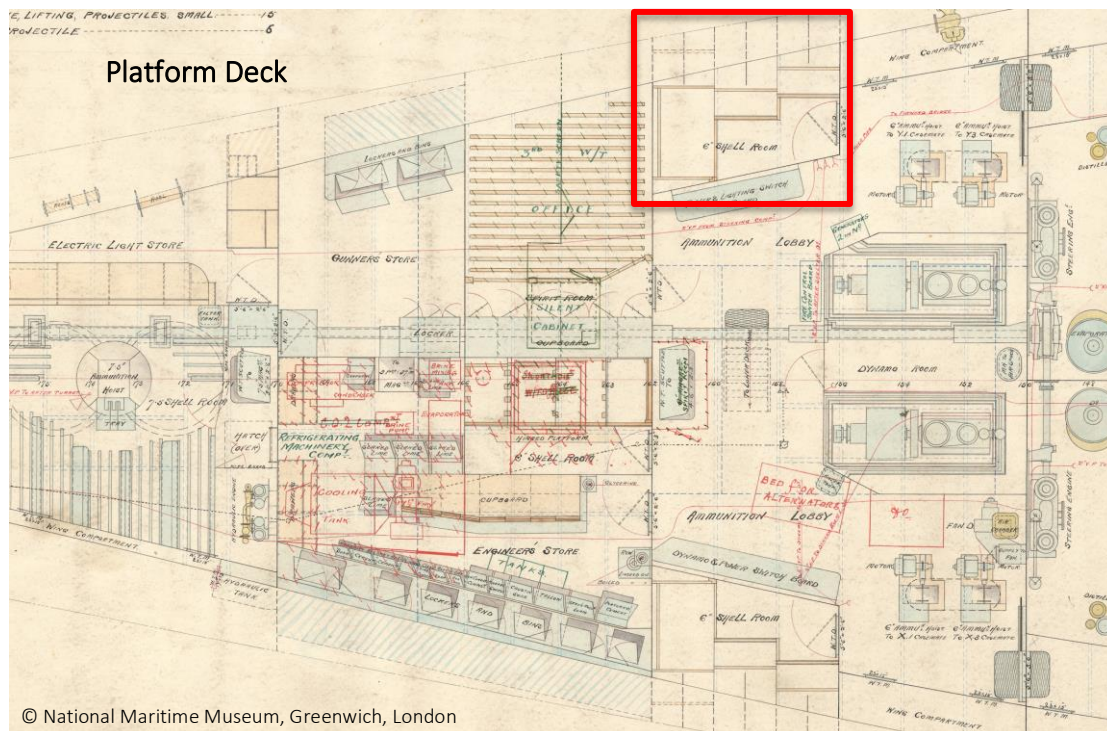


Figure 100: Ship's plans of stern munitions on Platform Deck and Hold

A variety of munitions are visible in the stern section of HMS HAMPSHIRE, both under the ship and within the fissure, including 6-inch shells, 7.5-inch cordite and 3-pdr cartridges. The fissure extends from the midships section to just aft of the stern casemates.

The port side 6-inch shell room for the aft casemate is exposed in the fissure. 6-inch shells are stacked in the remains of shell bins.



Figure 101: Port aft Shell Room. Sagging keel plating is seen to the left, having split and collapsed down to expose the shell room hard up against the port side of the ship to right of shot



Figure 102: A view from forward, looking aft of the port 6-inch shell room showing separation and collapse of hull bottom (right) from port side of the ship (left)

Collapsing of the hull underneath the free section of port prop shaft in the vicinity of Y-turret has exposed the 3-pdr magazines located in the Hold (see Figure 103).

Dozens of rounds of 3-pdr Vickers Mk1 QF fixed ammunition are present, each comprising of a brass cartridge containing cordite, and a corroded steel projectile containing fuze and explosive. Each round of ammunition is approximately 0.5m long and 5cm diameter.

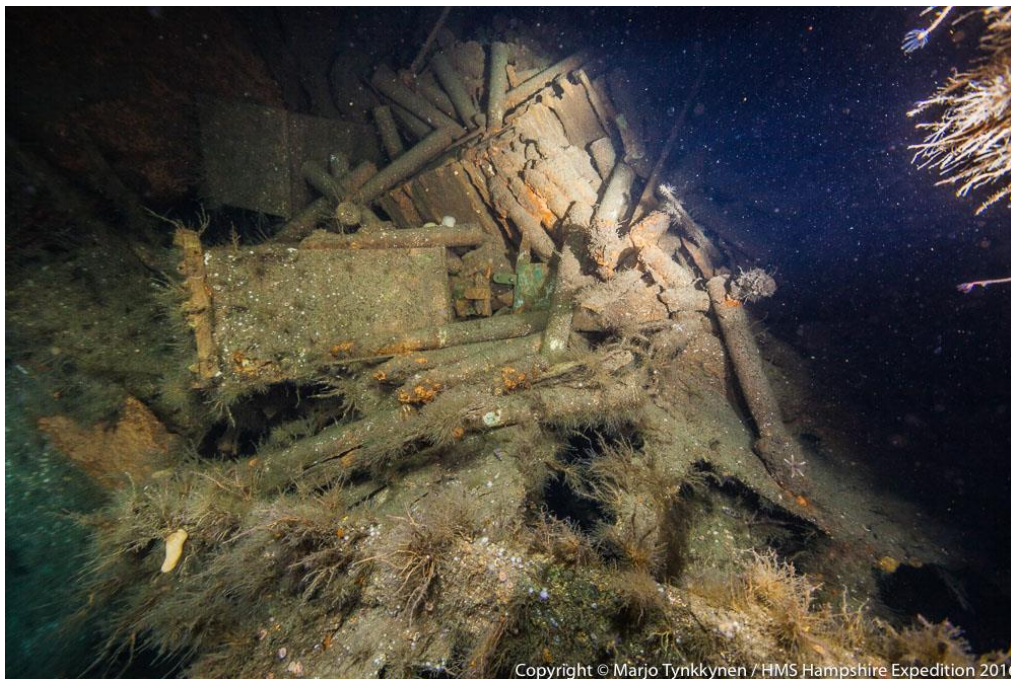


Figure 103: Vickers 3-pdr QF ammunition abaft Y-turret, directly under the port prop shaft

On the seabed in the area are the remains of the 7.5-inch Y-turret magazine. Ribbed flash-proof brass boxes of propellant and scattered cordite are spilled onto the seabed both to port and starboard.



Figure 104: A brass cordite case. A cage lamp with glass intact lies to its right

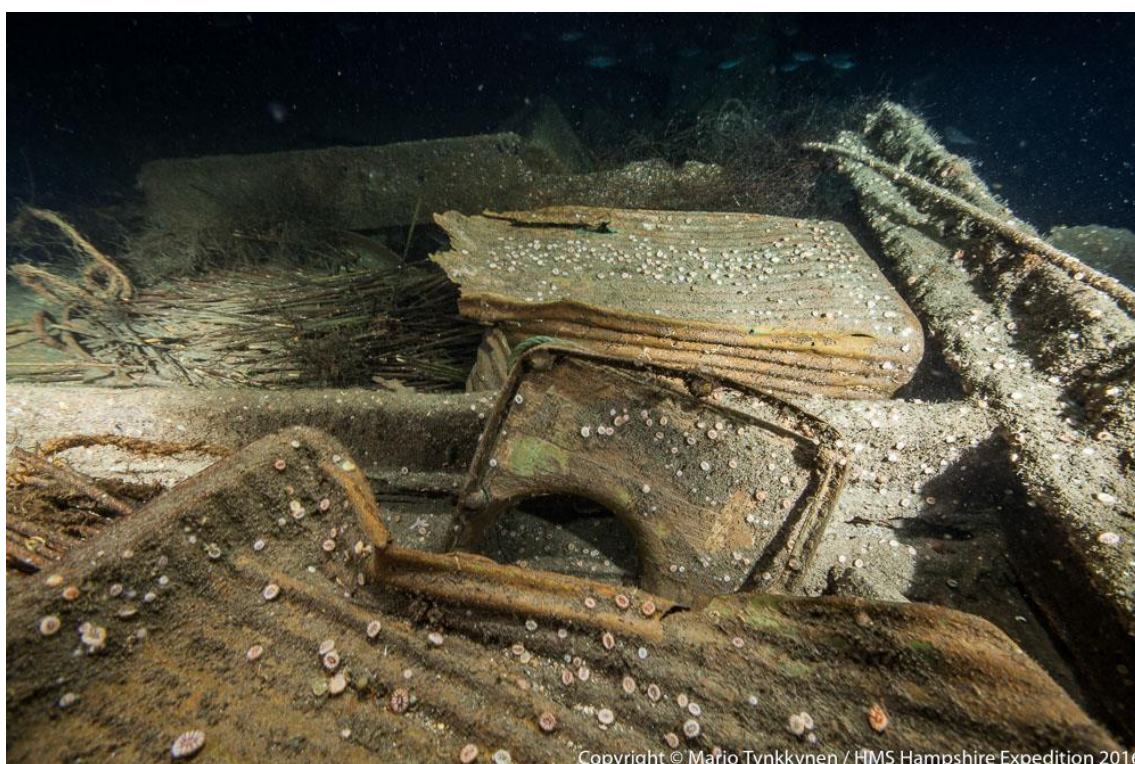


Figure 105: Ribbed flash proof brass cordite cases for 7.5" or 6" BL guns. These cases have sustained hydrostatic pressure damage and have burst open, spilling cordite sticks from within. The cordite would have been contained in silk bags, which have evidently rotted away



Figure 106: Cordite box lid on seabed



Figure 107: Boxes of cordite have fallen from the fissure on the port side to lie on the seabed

11.5.3 Stern Section Artefacts

Artefacts are scattered in the wreckage predominantly to the port side of HMS HAMPSHIRE, fallen from within the ship as the hull plating and internal structures have decayed.

Artefacts range from machinery orientated items to domestic items. The parts of the stern that have collapsed contained both sleeping and day quarters for the officers, and on the lower decks' machinery and engineering stores.



Figure 108: A copper oil filler lies on the seabed next to the main mast. This is similar to those found on small steam engines



Figure 109: Copper jug and electrical wiring



Figure 110: Earthenware container with intact stopper beside electric cabling,
on a wooden cable drum



Figure 111: Brass cage lamp



Figure 112: A single egg cup lies directly at the stern next to the ship's name



Figure 113: A brass drawer handle set into the remains of a drawer front.

Several flue cowlings were located on the wreck. The example in the image below is located on the port side of the ship. To starboard there are several similar items partially buried in the seabed.



Figure 114: H-shaped flue cowl for a cabin stove

11.5.4 Debris Field

A scattered debris field exists to the east side of the wreck and extends up to 40 metres. No artefacts were located to the west of the wreck. The artefacts identified in the debris field all originated from the open decks of the ship.

The most significant items found in the debris field were guns from the secondary battery. Near the remains of the foremast is the firing mechanism and breech end of a Vickers 3-pdr gun. At midships, some metres away from the ship, are scattered three of the four deck mounted 6-inch guns (the fourth remains in place under the ship). Two of the guns are rammed barrel first 3 metres deep into the seabed. The third lies flat on the seabed. Located on the seabed next to the 6-inch gun closest to the wreck was a semi-circular brass strip with visible markings dividing the strip into degrees. This was likely attached to the deck as part of the training mechanism for either a 6-inch gun or 3-pdr deck mounted gun.

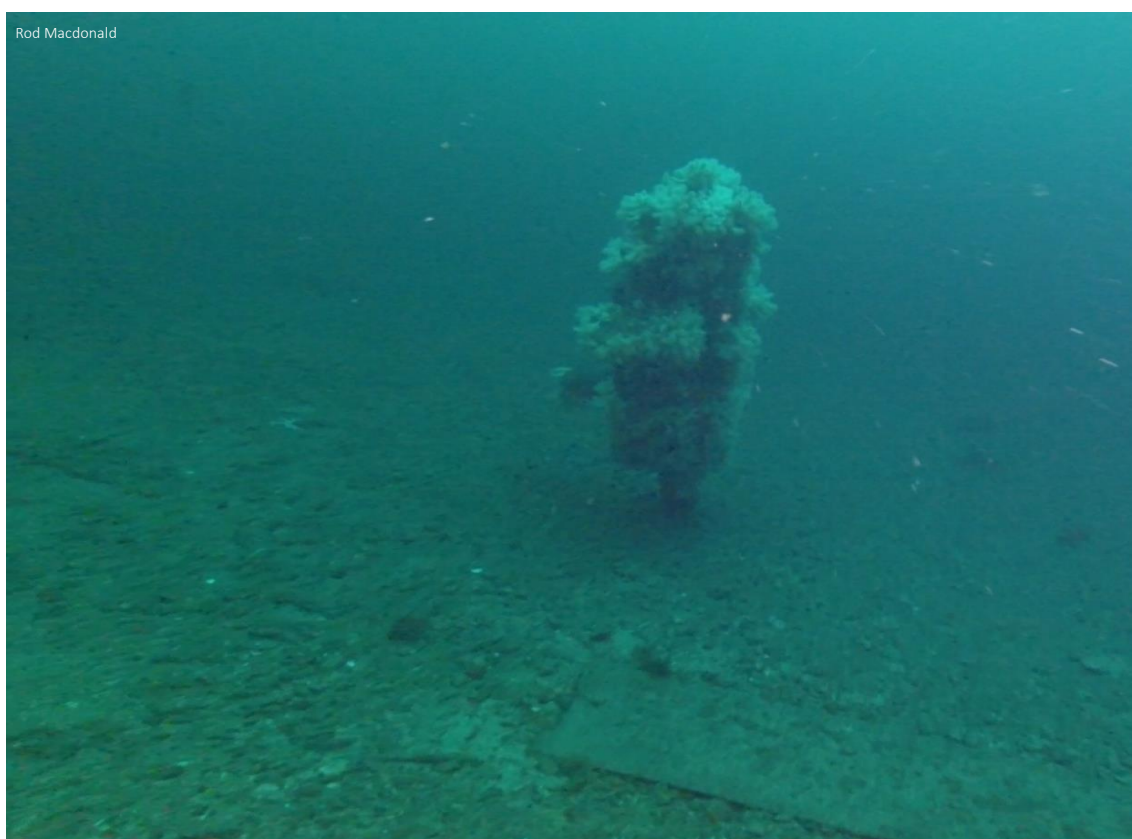


Figure 115: A 6-inch Vickers Mk VII gun has fallen from its mount as the ship capsized and impaled itself barrel first in the seabed

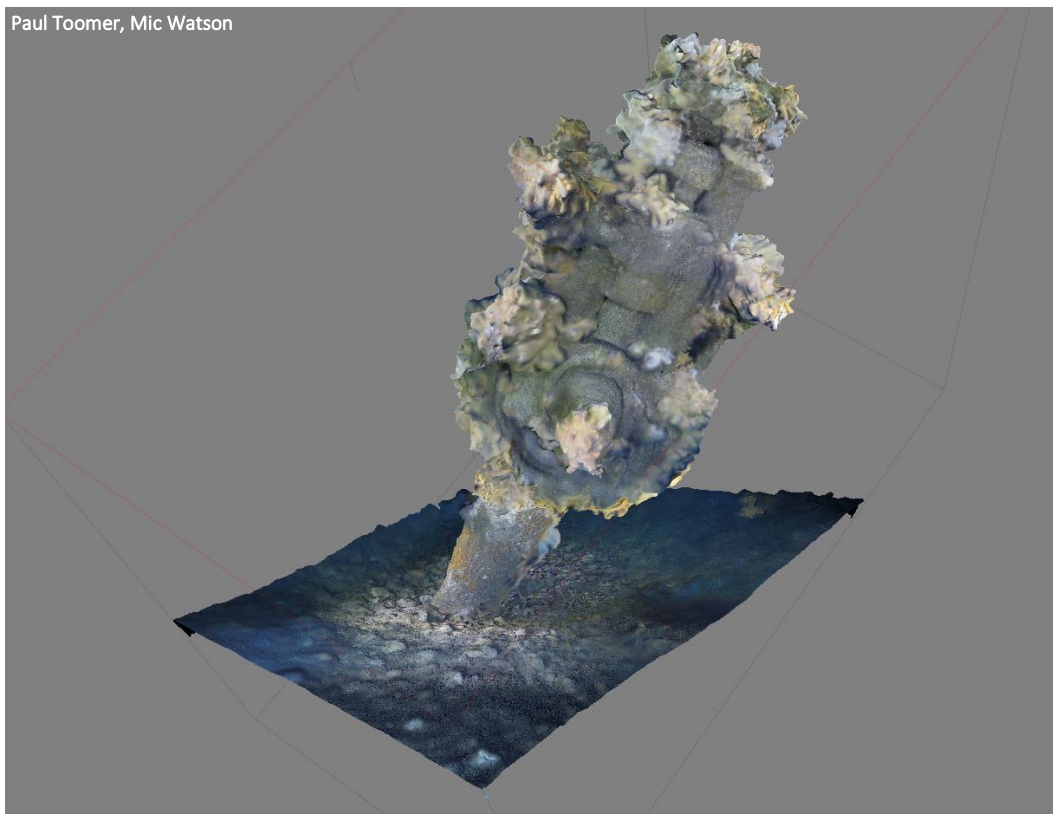
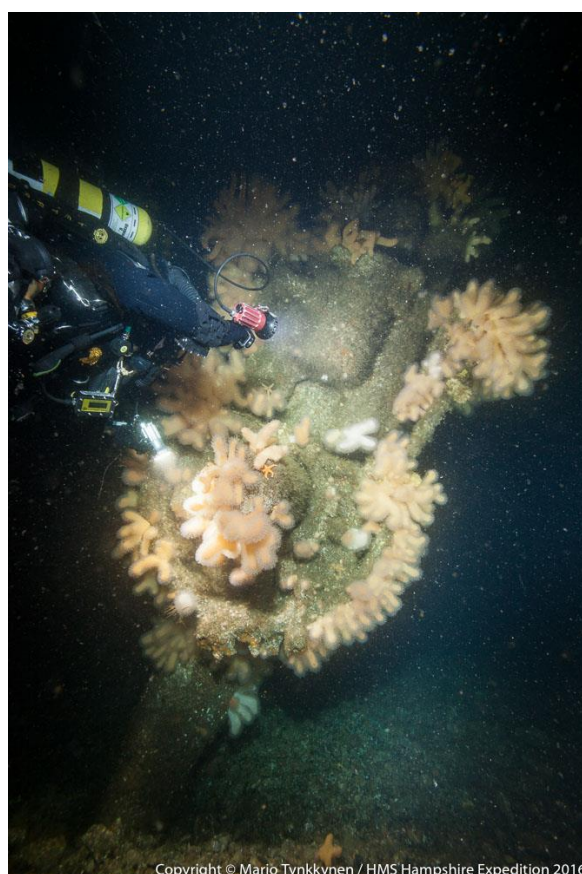
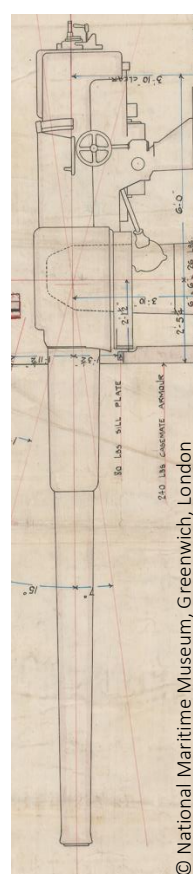


Figure 116: 3D photogrammetry of the 6-inch Vickers Mk VII gun fallen from its mount as the ship capsized. It impaled itself barrel first in the seabed



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Figure 117: A second Vickers Mk VII 6-inch gun has fallen from its deck mount as the ship capsized. Its barrel has penetrated 4-5 metres into the seabed like a dart. Alongside is a schematic of the Mk VII 6-inch gun

Both fore and aft masts were approximately 150 feet high. Both have been pushed to the port side as the ship sank, and the remains of both now lie on the seabed. Very little structure survives of the forward mast. Adjacent to this structure, however, lies one of the bridge telegraphs and one of the navigation lamps (presumably the port side lamp). No discernible structure remains of the upper spotting top or the upper mast and yardarms. The main mast is more complete at the lower levels. The spotting top and upper mast and yardarms are, for the most part, absent.

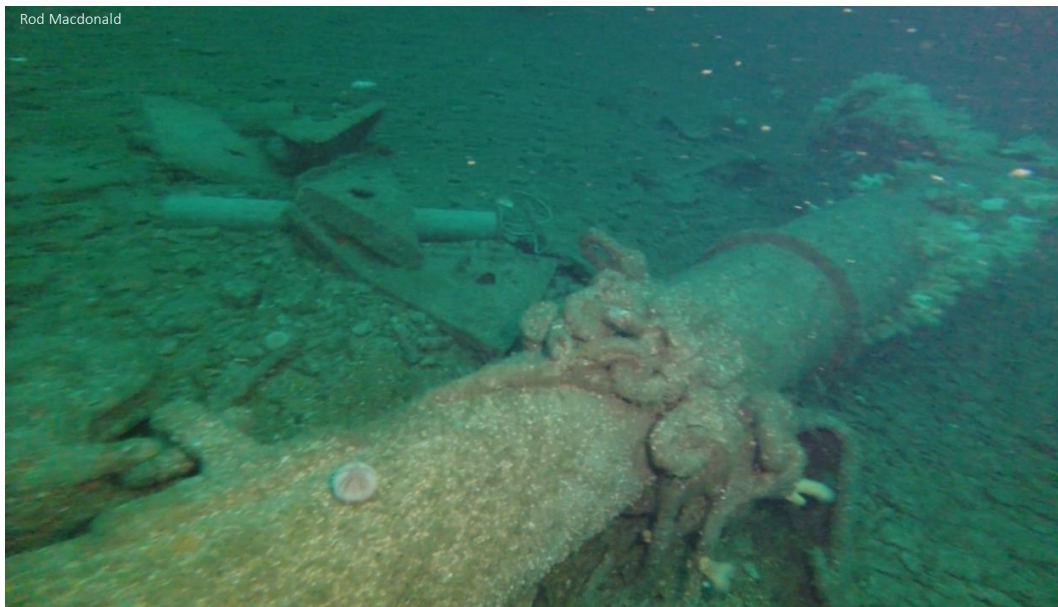


Figure 118: Main mast with shackles for standing rigging



Figure 119: A close-up view of debris next to the main mast. Triangular sections are the lower support for the spotting top platform

HMS HAMPSHIRE carried two steam pinnaces; both were lost when the ship sank. The remains of the first lies in the midships section of the wreck, the boiler for this pinnacle was located in the debris field lying just off the end of the main mast. A second similar boiler consistent with a steam pinnacle was located a further 10 metres away from the wreck from the first boiler. No additional wreckage from a second pinnacle was identified during the survey, apart from one single brass Samson post just aft of the foremast. This may, however, have come from any of the larger boats that HMS HAMPSHIRE was carrying. It is likely that the two boilers lying off the wreck in the debris field fell from their mounts through pinnacle deck house roofs as the ship capsized.

12. Discussion

HMS HAMPSHIRE struck a single German Hertz horn mine at 8.40pm while approximately 1.5 miles off Marwick Head in Orkney. The weather was bad, with a force 9 gale blowing from the north west, which is estimated to produce a wave height of 7 metres.

The mine was laid by U 75. The mine was tethered to the seabed and floated at a depth of 7 metres. HMS HAMPSHIRE's mean draught was 7.5 metres.

When the remaining mines of the minefield laid by U 75 were subsequently swept, they were found to be anchored at a depth of less than 7 metres. Some were reported to be tethered at a depth of 4.5 metres below the surface of the water at low water.

HM Drifter LAUREL CROWN struck a mine in the same field on 22nd June 1916 (some two weeks after the loss of HMS HAMPSHIRE) whilst mine sweeping in the area of HMS HAMPSHIRE's loss. Nine lives were lost. Her draught was in the region of 10 feet – approximately 3 metres.

HMS HAMPSHIRE's draught was more than deep enough to hit the mine and the sea conditions would only exacerbate this risk.

HMS HAMPSHIRE hit the mine in the forward part of the ship as she steamed into the minefield. The only visible signs of blast damage to the ship found during the survey is seen on the forward brass bulkhead of the lower conning tower. This is uniformly bent across its width to almost ninety degrees along its lower edge, suggesting that the explosion from the mine was very close to this position.

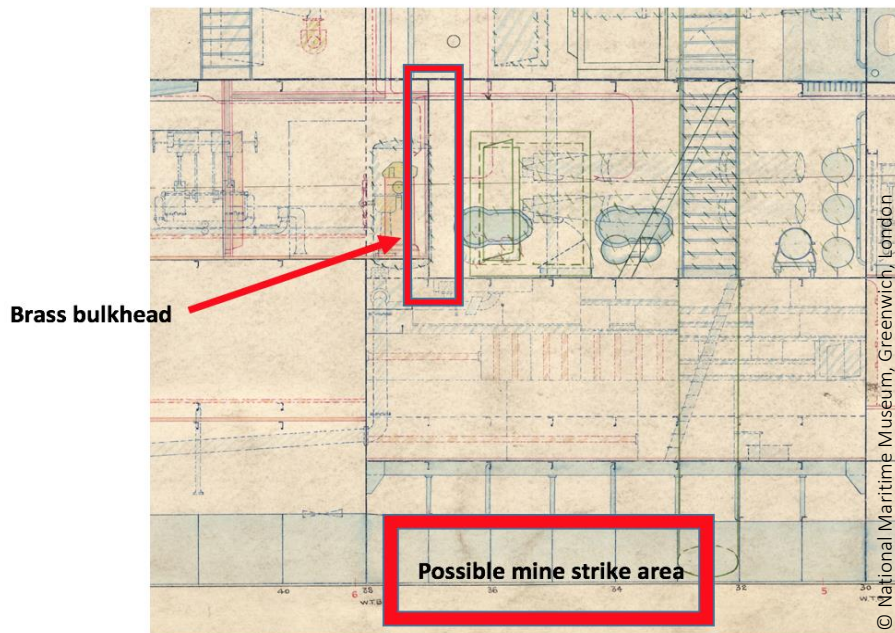


Figure 120: Ship's plan extract detailing position of possible mine strike and location of lower conning tower brass bulkhead

12.1 Mine Damage to the Ship

- The detonation of the mine against the hull of HMS Hampshire would have directly caused shock, blast and flash to enter the ship causing structural damage, bending, cracking, joint failure, and then consequential flooding through the break in the hull.
- The ship was being navigated at speed in heavy weather, the speed and surge of water past and into the break in the hull would have caused additional hydrostatic damage to the ship's structure, increasing the rate of flooding, internal and external damage.
- Blast and flash (fireball) would have entered the ship's air spaces, cabins and companionways causing injuries and fatalities to crew in affected compartments. The combination of shock, blast, flash, fire and shrapnel could have caused sympathetic

explosion of ammunition, torpedoes and mines, however no evidence of this has been observed during the survey.

- The images of the cylindrical 7.5-inch ammunition hoist trunking and the capstan shafts show no evidence of blast damage. Therefore, the mine is more likely to have hit aft of the 7.5-inch turret. It must have hit forward of frame No 38, as the ship is intact at this point.
- The imagery of the torpedo room area clearly shows a brass bulkhead bent through at approximately 90 degrees, with crack damage to the stiffeners consistent with mine damage. The damage to the bulkhead is relatively symmetrical suggesting that the explosion was aligned with it along or close to the central axis of the ship.
- The armour belt along both sides of the ship is remarkably intact and well aligned, suggesting that the mine explosion was not close to it on either side of the ship.
- There is an absence of explosive damage further forward on the 7.5-inch ammunition hoist trunking of A-turret and to the three capstan shafts.
- The large number of intact propellant cases and torpedo/mine warheads indicates that no secondary explosion of embarked munitions took place.
- The brass bulkhead is consistent with the internal walls of a lower conning tower. It is almost certainly the bulkhead between the lower conning tower and the torpedo room. This puts the likely strike area of the mine to be between frame Nos 32 and 38, towards the centre line of the ship. The nominal draught of the ship at this point is 7.6 metres (24'9") which is consistent with the nominal mooring depth of the mines laid by U 75.
- There is considerable damage to the forward edge of the lower control room consistent with explosive damage.



Figure 121: Bulkhead looking to port across the ship: note the cracking damage

Survivors reported that the explosion seemed to be on the port side of the bow. The uniform damage to the lower conning tower bulkhead suggests that if this were the case it must have been very close to the centre of the ship. However, this might explain why the port side torpedo tube is missing. Further remote survey in the area may be able to locate the missing tube on the seabed and therefore identify the actual geographical position when the ship struck the mine. It is also possible, however, that the tube was illegally salvaged. It is less likely that the tube is buried and therefore not visible because the torpedo door opening through the side of the hull is clearly visible above the debris and the 7.5-inch Shell Room for P-turret is also clearly visible, which was located on the same deck level as the torpedo tubes.

As would be expected with damage to the forward section of the ship, HMS HAMPSHIRE settled bow first. Eyewitness accounts describe the stern and propellers clear of the water.

HMS HAMPSHIRE is 144 metres long, and she sank in 65–68 metres of water. An analysis of the ship's plans suggests that for the propellers to be clear of the water her stem may have

been in contact with the seabed. There is no damage to the forefoot of HMS HAMPSHIRE observable today. It is possible that sufficient reserve buoyancy in the stern section of the ship allowed her to be clear of the water from stern to midships, with her bow submerged but not in contact with the seabed.

Today the ship lies upside down on the seabed with a list to starboard, and a debris field to the east of the site. The ship must have occupied the water whilst capsized to the east of her current position on the seabed while debris fell from the deck. She has then moved towards the west before settling on the seabed. The force required for the 6-inch guns to impale themselves 3 metres into the seabed requires a significant depth of water and indicates that they fell from the capsized ship at or near the surface.

The tidal flow was setting to the north west at the time of her sinking. Once a sufficient proportion of the ship was underwater, the tide would have a greater effect than the wind and swell, causing her to pivot towards the north west moving over 40 metres from her original capsized position before settling on the seabed.

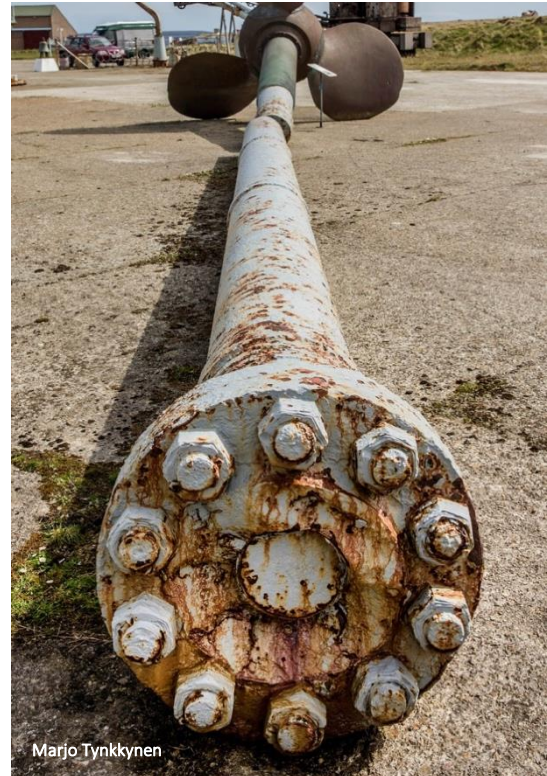


Figure 122: Diagram indicating wind direction and tidal direction on the evening of 5th June 1916

When the starboard propeller was salvaged in 1983 it was reported to have been lying on the seabed and not attached to the wreck. The severed end of the shaft, currently housed at the Scapa Flow Visitor Centre in Hoy, provides evidence that the shaft was snapped, and not cut.



Figure 123: The broken flange joint of the starboard side prop shaft housed at Sapa Flow Visitor Centre



- The fracture surface of the propeller shaft where it is broken from the ship is adjacent to a bolted flange joint.
- There is no sign of blast damage to the bolted joint or flange.
- There is evidence of cup and cone fracture surfaces consistent with a bending fracture mechanism. Essentially, it has bent and snapped either when the ship hit the seabed or subsequently as the ship has decayed, or possibly through illegal, commercial salvage works.
- The current condition of the port propeller shaft on the ship shows signs of stress consistent with the location of the break on the starboard shaft on the ship.



Figure 124: The starboard shaft was cut just aft of the propeller post-salvage



- The starboard shaft has been cut just forward of where the cutlass bearing would have been. This cut has been made post salvage, as archive images of the landed artefact show the shaft and propeller as a composite unit. It is suggested that the cut may have been made in order to ship the items to Lyness.

- The starboard side A-frame was also recovered with the propeller and has associated damage consistent with fracturing.



Figure 125: Starboard side A-frame bracket

The long arm has not been cut. The fracture surface on the long leg of the A-frame shows some evidence of a cup profile and shows no evidence of cutting, see Figure 126, below.



Figure 126: Fracture surface of A-frame

In its current position at Lyness it is not possible to examine the fracture surface of the short arm. Without lifting the object to photograph the surface, we cannot say with any certainty if it is a break or a cut.



Figure 127: Starboard side A-frame bracket showing the severed short arm

Examination of the footage of the remaining port A-frame clearly shows the cutlass bearing extends further aft than forward of its supports.

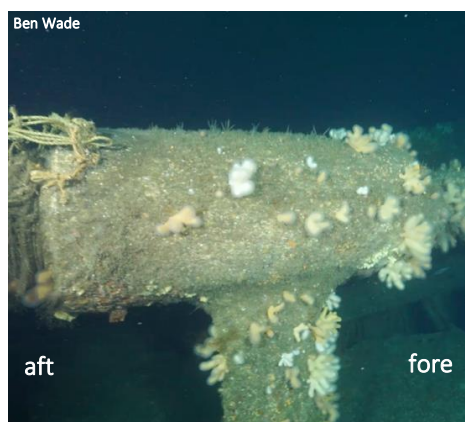


Figure 128: Comparison of starboard and port A-frames, detailing fore and aft position

This enabled us to orientate the A-frame and bearing at Lyness, such that the remaining short arm was the upper leg on the ship. The remaining long leg would have been attached to the keel.

Other artefacts are known to have been salvaged from HMS HAMPSHIRE, including three 3-pdr Vickers guns now housed at the Scapa Flow Visitor Centre in Lyness, and at the bottom of the footpath to the Kitchener Memorial on Orkney Mainland. A 12-pdr gun is also believed

to have been salvaged from the wreck at this time. Other smaller items were also recovered during the 1983 survey, including several scuttles (portholes), and a brass ship's wheel small enough to be from one of the ship's boats. With the advent of technical diving, the wreck of HMS HAMPSHIRE became a recreational dive site before her closure in 2002. It is known and documented that many small artefacts were removed during this period.

The bow section of the wreck shows signs of the mine blast that sunk her and 100 years of decay. The frames, stringers and shell plating of the hull forward of frame No 38 to the stem are missing. The survey found no definitive evidence of salvage work to the main body of the ship. However, the corrosion and collapse of the forward part of the hull plating makes it difficult to rule out such salvage work. The vertical armour belt is intact on both sides of the ship, and intact glass navigation lamps and porthole glasses located in the very bow suggest that large demolition charges had not been used in the hull. This area of the ship has been damaged by the mine strike and will have accelerated the rate of decay and collapse in this area, compared to the rest of the ship.

An intact navigation lamp showing possible compression damage from sinking lies in the bow. The glass is intact in the lamp. These were likely held in the boatswain's store which, on the ship's plans, is marked in this part of the bow. In addition to the pressure damage visible on the navigation lamp in the bow, several dozen ribbed brass cordite propellant storage boxes also show evidence of pressure damage consistent with all propellant boxes located on the wreck. Nowhere was there evidence found of explosive damage to the boxes.



Figure 129: Intact navigation lamp

The anchor capstan drive shafts now appear to sit higher than their original position in relation to the remaining ship's hull structure. It is possible that as the Upper and Main Decks

collapsed under the ship, the anchor capstan drive shafts have risen upwards above the height of the keel. The drive shafts are undamaged, and this suggests that the keel and associated hull plating at this point must already have been absent. It is likely that the mine therefore severed the keel, and that the keel was already bent to starboard before the collapse of this area pushed the capstans upwards.

The hull aft of frame No 38 is degraded but relatively intact. Two large longitudinal fissures have opened up in the hull, one to port and one to starboard and these run the length of the midships section. At the time of the survey the starboard fissure is noticeably narrower than the port one. The likely cause of the fissures is a combination of the Main Deck decaying and collapsing and the physical weight of the armoured belt pulling the side of the ship down towards the seabed. A potential weakness in the hull structure in the form of two ammunition passageways that run the entire length of the space currently occupied by the fissures may have exacerbated this weakness, given the length of time upside down underwater and the associated decay.

The Main Deck, which is only visible on the port side, has reduced in deck to deckhead height from 2.5 metres at her time of construction to approximately 1 metre at the time of the survey, as shown in Figure 130. It is noteworthy that this has remained stable, and does not seem to have decreased considerably between the 1999 and 2016 images. The associated hull plating along the midships section has fallen away and now lies face down on the seabed.

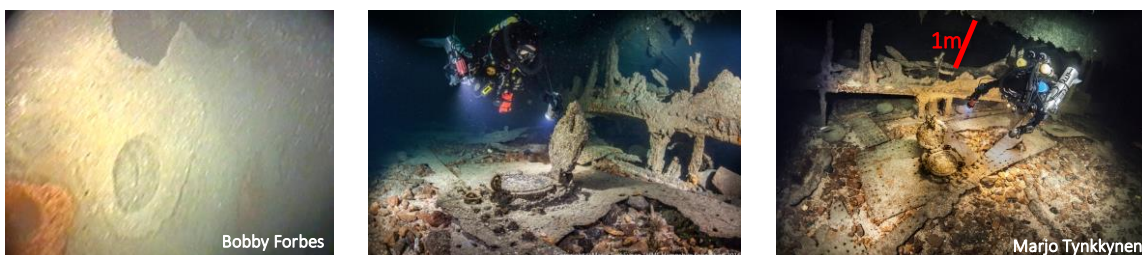


Figure 130: Hull plating

The hull plating fallen to the seabed outside the wreck contains portholes from the Main Deck. These were mostly in situ circa 2000.

With the decay of the Main Deck, the vertical armour belt was able to settle towards the seabed under its own weight. This process has allowed the port side fissure to form at the weakest part of the hull structure, which is now above the vertical armour belt and armoured deck, in her capsized form. This decay may have been exacerbated by a longitudinal ammunition passageway running the entire length of the midships section.



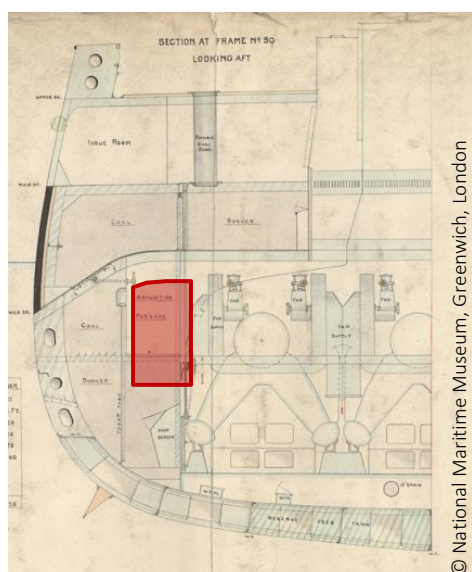
circa 1999



2016

Figure 131: Images comparing distance between upturned hull and seabed. Note Vickers gun firing trigger

The starboard side fissure is much smaller. As the starboard vertical armour belt was in contact with the seabed at the time of sinking, the cause of the fissure must be entirely due to decay. The starboard longitudinal fissure, however, follows the same approximate pattern as on the port side of the hull. It is anticipated that both starboard and port longitudinal fissures will continue to grow and fracture the hull.



© National Maritime Museum, Greenwich, London

Figure 132: Cross section of the ship's plans showing port side ammunition passageway

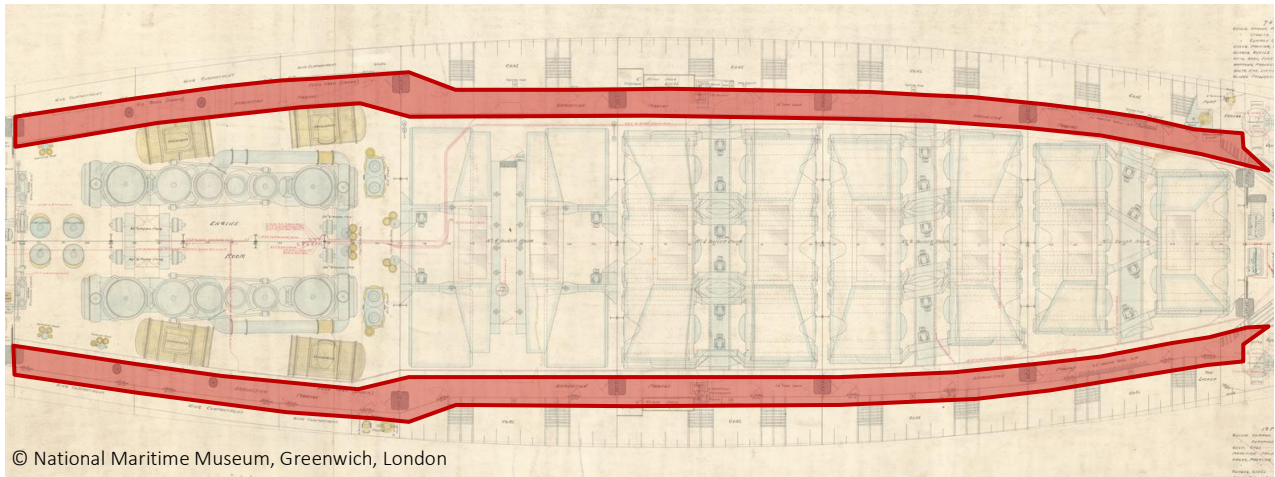


Figure 133: Ship's plans showing the location of the longitudinal ammunition passageways

The stern section has suffered severely from saltwater corrosion and decay. The Main Deck and Lower Deck have mostly rotted away, leaving only the Platform Deck and the Hold relatively intact. The Platform Deck is supported by the armoured deck at seabed level while the keel is supported by Y-turret's ammunition hoist. The port side propeller and shaft remain intact, although the shaft is showing signs of stress at the stern tube where circled in red, below. It is anticipated that this will snap over the course of time.



Figure 134: 3 image of port side propeller and shaft

Much of the remains of the Main Deck and Lower Deck hull plating lie on the seabed to port and starboard. There is visible seabed scouring under the starboard side of the stern and large quantities of debris from the corroded stern section remain under the wreck and the surrounding area, roughly within the original footprint of the ship.

In addition to the three 6-inch guns located in the debris field, two small Yarrow-type pinnacle boilers were also identified, displaced from any pinnacle remains. One boiler landed on the seabed beyond the main mast, some 20 metres away from the wreck. A second similar boiler consistent with a steam pinnacle was located another 10 metres further away from the first boiler.

HMS HAMPSHIRE carried two steam pinnaces, one 40 feet and one 56 feet long. The remains of one is located alongside the ship in the midships section. No confirmed remains were found for the second steam pinnacle, except for the boiler. Both steam pinnaces would have been in the stowed position when HMS HAMPSHIRE hit the mine. Due to the loss of power after the mine strike it is unlikely that the crew would have attempted to launch either of these boats during the sinking. Therefore, these boats would have initially capsized with the ship in their stowed position, but in the capsize process they may or may not have broken free from their stowed position. During the capsize process the boilers would be free to fall from their mounts in the boats to land in isolation on the seabed below. Each boiler would have been mounted in a cradle relying predominantly on gravity to keep them in place, secured, at most, by lightweight fixings. During the capsize process the weight of the boiler would break these fixings, allowing it to fall through the pinnacle roof to the seabed.

Only three Carley rafts made it to shore intact. Reports exist detailing that of the remains of several boats also washed ashore including:

- a dinghy,
- a pinnacle,
- a whaler,
- a cutter.

It is possible that the remains of the pinnacle are that of her second steam pinnacle, assuming it capsized above the debris field, thus allowing her boiler to be deposited. Alternatively, HMS HAMPSHIRE also carried a sailing pinnacle which could account for the pinnacle remains washed ashore.

Other items of unsecured gear fell from the ship as she capsized to starboard, creating the debris field to the east of the wreck. The survey did not find any debris associated with the sinking of the vessel on the west side of the wreck.

13. Conclusions

The wreck of HMS HAMPSHIRE is an excellent example of a pre-WWI armoured cruiser. She is structurally intact except for the blast damage from the mine that sank her, possible salvage work and the subsequent decay due to saltwater corrosion. The wreck site is confined to the footprint of the ship and a debris field extending some 40 metres to the east of the wreck.

She lies upside down. The process of her capsize is likely to have been a complex manoeuvre influenced not only by wind and waves but also tidal flow. The mine damage allowed flooding to the forward part of the ship causing the bow to submerge first. Her keel bar was likely severed by the mine strike. At some point during the capsize manoeuvre her bow would have been very close to or touching the seabed. Her forefoot remains intact. She capsized slightly to the east of her current position, depositing debris in this area, including three 6-inch guns mounted further aft on her deck and two pinnace boilers. As the ship became submerged, momentum from her capsize, allied to the tidal effect, would take control of the ship's movement through the water column pushing her in part to the west. It is likely that the ship pivoted on her upturned bow.

Her depth, geographical position and the tidal waters she lies in required substantial planning and the implementation of a controlled technical dive survey. A dedicated diving safety officer controlled all dive planning, dive equipment and gas management. Special consideration was given to the dive team in both skillset and attitude.

Access to sidescan sonar data before the survey was vital to gain an overall understanding of the site and to plan the in-water survey activity. Further use of remote survey would provide the basis for new survey work and enable additional important evidence to be gathered informing the sinking event.

Artefacts are visible around the site, some in the debris field fallen from the open decks during the sinking event. Further artefacts are visible because of the damage and decay to the ship which have allowed items to fall from the ship to their current positions on the seabed. Other artefacts and internal architectural features are visible within the open areas of the ship caused by mine damage and decay. Wreck penetration is not required to view these items and was strictly prohibited under the license terms.

Evidence of salvage exists on the site mainly in the absence of the starboard propeller and some small guns. Additional removal of artefacts is confirmed due to published accounts from recreational divers and the location of confirmed HMS HAMPSHIRE artefacts in local museums. The damage to the bow area is extensive, with missing keel frames, stringers and keel plating and the survey cannot rule out commercial salvage work that may have increased the original mine damage. However, no evidence was found during the survey to suggest direct salvage to the wreck in this area, and the decay is consistent with other areas of the ship.

The designation of the wreck as a controlled site in 2002 has ensured the ongoing preservation of the site. Controlled access to the site in the future would provide the opportunity for a long-term corrosion study and further work to be undertaken into the events of the sinking and possible salvage of the site.

Teamwork was key to the success of the survey. The combination of in-water wreck diving specialists, underwater photographers, videographers and 3DPG experts and post survey consultation with subject matter experts proved highly successful. The diving methods employed during the survey worked very well and are reflected in the survey results. The HMS HAMPSHIRE 100 survey lays a solid foundation for underwater war grave wreck survey projects, demonstrating that volunteer teams can produce a very high standard of work from which further wrecks surveys have developed e.g. HMS VANGUARD 100 survey (2016/2017) and HMS ROYAL OAK 80 survey (2018/2019).

The use of technical diving equipment was, in this case, imperative along with employing team diving techniques, enabling effective survey data to be collected at depths below 65 metres in tidal water both efficiently and safely. Similar surveys should consider the dive platform to be used, ensuring its effectiveness and suitability. Surface cover and a skilled boat crew are also vital to the safe implementation of deep water tidal team diving.

Digital underwater camera equipment allowed the site to be documented. Dive teams carrying small HD/4K video cameras for broad scale documentation and artefact location proved highly successful and allowed the documentary team the freedom to photograph/video key features. 3D photogrammetry allowed large sections of the site to be accurately documented and the techniques used both in-water and post processing have helped lay the foundations for recent deep-water 3D mapping by divers.

The survey has collected a rich body of information and imagery and made it available to the wider public and the historical record. Access to controlled sites by professional volunteer teams passionate and dedicated to the project allows a body of work to be gathered and shared providing a wide audience, both national and international, visual access to the site. They gather important data for future research which would otherwise be at risk of being lost and, in this case, it ensures that the memory of HMS HAMPSHIRE and the sacrifice made by her crew is never forgotten.

14. Outputs

In addition to publication of this report, a number of different media have been prepared.

- Survey information and imagery was used to contribute to a new book published in 2016: *HMS HAMPSHIRE, A Century of Myths and Mysteries Unravelling*, James Irvine et al.
- A series of talks and lectures to interested bodies has been undertaken:
 - Orkney Science Festival 2016, Orkney, UK;
 - OZTeK Dive Conference 2017, Sydney, Australia;
 - TEK Dive USA Dive Conference, Orlando, Florida, USA 2018;

- Eurotek Dive Conference 2018, Birmingham, UK;
- The Shipwreck Conference 2018, Plymouth.
- Media based dissemination of information has been undertaken, including newspaper and magazine articles.

15. Report Distribution:

This report will be made available for free download. In addition, copies will be housed with the following bodies:

1. The Explorers Club, New York;
2. Royal Navy Third Sector, Portsmouth;
3. Naval Historical Library, MOD;
4. Orkney Museums and Heritage, Scapa Flow Visitor Centre and Museum;
5. Orkney Natural History Society Museum, Stromness Museum;
6. Imperial War Museum, London;
7. National Maritime Museum, Greenwich;
8. Historic Environment Scotland;
9. War Graves Commission.

16. Recommendations for Future Work

1. It is recommended that the survey be repeated every 2 – 5 years to monitor the site, record deterioration and provide an opportunity to extend the 3D photogrammetry and photographic documentation. This information should be widely shared in an appropriate manner.
2. Additional remote survey of the surrounding site should be undertaken to search for wreckage and artefacts out with the surveyed area.

3. HMS HAMPSHIRE should continue to be treated as a site of great historical importance. She is a time capsule into pre WWI-Naval architecture and provides an opportunity for study into shipwreck decay. Methods used by the HMS HAMPSHIRE 100 survey team have been shown to be highly effective. The techniques were further developed and used by team members to conduct surveys of HMS VANGUARD (2016/2017) and HMS ROYAL OAK (2018/2019).

17. APPENDIX I: Diving Specific Project Methods

17.1 Survey vessel

Diving was conducted from the dive vessel MV Huskyn, skippered and owned by Emily Turton and Ben Wade, both of whom are highly respected Scapa Flow dive vessel operators and Orkney shipwreck amateur diver historians. Turton and Wade were co-organisers for the expedition and were part of the survey team. Constructed in 2015, this 16m steel hull, twin-engine purpose-built dive vessel is the most modern and outfitted vessel of its type in European waters (www.huskyan.com).

17.2 Diving methodology

1. *Diving Experience*

All diving participants were trained and experienced in mixed gas and accelerated decompression diving techniques. The maximum number of expedition divers aboard MV Huskyn was twelve (12), supported by one dive vessel crewman and a skipper.

2. *Expedition Participants and Diving Roles*

In order to achieve the expedition objectives, each team member was required to fulfil a dedicated role, either in a primary capacity, such as photography or videography, or in a supporting 'dive buddy' role.

3. *Dive Team Minimum Size*

The minimum dive team size was a 'buddy pair.' Buddy pairs were grouped together to form larger teams as necessary. No solo diving was permitted.

4. *Primary Life Support*

For logistical reasons there was a strong preference that all divers use an electronically controlled Closed-Circuit Rebreather (CCR). Although not mandatory, the use of CCR assembly and test hard copy checklist was strongly encouraged.

5. Secondary Life Support

All divers were required to carry sufficient open circuit bailout gas to independently support a full open circuit decompression profile in the event of a catastrophic failure of primary life support. As a minimum, divers were required to carry an 11-litre cylinder of bailout 'bottom gas' (minimum pressure 210 bar) and an 11-litre cylinder of decompression gas (minimum pressure 210 bar) or equivalent.

6. Bailout Cylinder Carriage

To help avoid incorrect gas use in the event of having to share open circuit bailout gas supplies, the 'rich right,' 'lean left' protocol was applied throughout the expedition. All divers carried the trimix bailout 'bottom gas' on their left side and the 60% nitrox decompression gas on their right side.

7. Bottom Time

To enable the carriage of sufficient open circuit bailout gas to support a self-contained open circuit bailout profile, run times were restricted to approximately 100 minutes, limiting 'bottom time' on the wreck to approximately 35 minutes. Where a specific task required the bottom time to be extended, the maximum run time was reviewed as required

8. Dive Teams

Dependent upon each day's objectives, available daylight and state of tide, a single wave of divers or two waves of smaller groups was conducted in a single day. Each diver was restricted to a single deep dive ($\geq 50\text{m}$) per 24hr period.

9. Decompression Planning

Divers were permitted to use their preferred decompression-planning tool, but were required to have a redundant decompression schedule either in the form of a second Personal Decompression Computer (PDC) or hard copy of both primary and secondary life support decompression plans.

10. Surface Identification and Safety Aids

All divers were required to carry a minimum of one (1) personally identifiable or named orange / red coloured Delayed Surface Marker Buoy (DSMB), together with a dedicated DSMB reel with sufficient line to enable DSMB deployment from the seabed at 70m. In addition, the following surface identification and safety aids were required to be carried by all divers:

- whistle,
- flag,
- yellow DSMB.

The following rescue aids were recommended:

- Personal Location Beacon (PLB) within a pressure proof housing,
- flare within a pressure proof housing,
- intermediate pressure air horn.

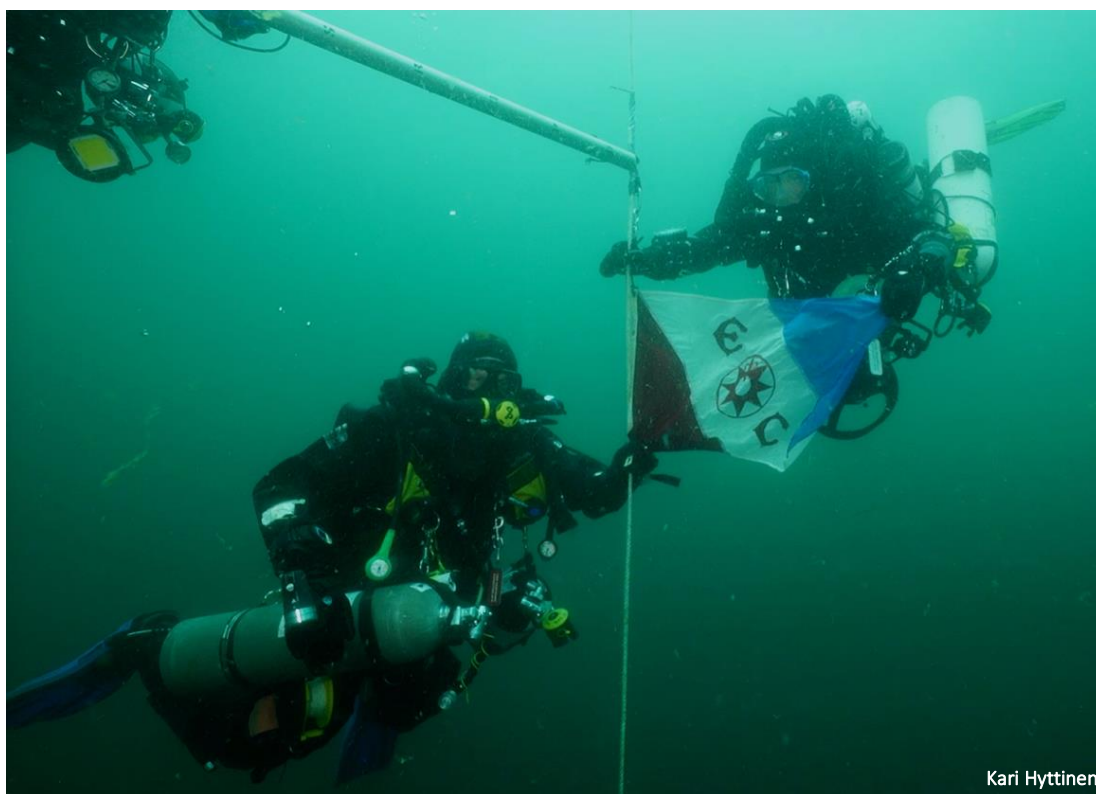
A description of each individual's emergency location aids was collated by the expedition Diving Safety Officer and stowed on the bridge of MV Huskylan to assist with searching in the event of a missing diver.

11. Wreck Location and Marking

The wreck of HMS HAMPSHIRE was located on the first day of diving the site using Global Positioning System (GPS) and Sound Navigation and Ranging (SONAR)/echo sounder. Once located, the wreck was shotted near the stern and bow. These shot-lines were then secured to the wreck to enable their use throughout the expedition. The use of two shot-lines enabled a direct descent to either end of the shipwreck, thus optimising 'bottom time' on a chosen section of the site, whilst providing an alternative emergency ascent option should divers find themselves short on 'bottom time' or in need of having to urgently ascend. All shot-lines and shot-weights were recovered at the end of the expedition.

12. Decompression Trapeze

The use of a two bar (6m & 9m) decompression trapeze throughout the expedition enabled the group tracking of decompressing divers from the surface. In addition, divers grouped together offered mutual support in the event of a diving emergency. The decompression trapeze was secured to the stern or bow's shot-line by a transfer line on a daily basis. Despite deploying two shot-lines, failing an emergency ascent, all divers were required to ascend to the trapeze on each dive and decompress as a group.



13. Decompression Trapeze Deployment

Each day a diving pair was selected to enter the water first and secure the decompression trapeze to the chosen shot-line at the appropriate depth before continuing their descent to the shipwreck.

14. Trapeze Emergency Decompression Gas Deployment

Each day a diving pair was selected to enter the water a few minutes after the first pair and secure an 80% nitrox cylinder to the trapeze at 9m. A second pair of divers then entered the

water and secured the deep bail out cylinder of 15/50 trimix at a depth of 30m where the transfer line was connected to the main shot line.

15. Diver Down / Up Logging System

A diver 'down / up' logging system using named tags was employed to monitor who had left bottom and ascended to the trapeze. Individual divers clipped their named tags to a brass ring in the transfer line at a depth of 30m on the descent. Divers removed their tag from the ring as they ascended and moved along the transfer line to the trapeze for decompression. The last diving pair ascending disconnected the trapeze from the shot-line before continuing their ascent up the trapeze transfer line.

16. Dive Safety Brief

A daily dive safety brief was presented by the expedition Diving Safety Officer, which included a weather outlook, dive-teams, objectives and a reminder of emergency protocols. All divers were required to attend the daily dive safety brief.

17. Daily Debrief

A daily debrief took place aboard MV Huskylan following completion of the day's diving. Feedback from the expedition team (surface support and divers) was used to consolidate the group's growing knowledge of the shipwreck, update one another on specific task progress, and to modify subsequent diving methodology. All divers were required to attend the daily debrief.

18. Breathing Gas Selection

For both diving safety and ease of logistics, all breathing gases were standardised. All divers used the following standard gases:

- CCR diluent: 15% oxygen, 50% helium, 35% nitrogen.
- Open circuit bailout: 15% oxygen, 50% helium, 35% nitrogen.
- Open circuit decompression: 60% and 80% nitrox.

19. Bottom Gas Selection

A trimix diluent of 15/50 provided an Oxygen Partial Pressure (PO₂) of 1.2 bar at 70m (maximum depth), thus facilitating an effective diluent flush without the safety implications of using a 'lean' hypoxic gas. In addition, at maximum depth this gas provides an approximate Equivalent Narcotic Depth (END) of 25m, which minimised breathing gas density, retained CO₂ and nitrogen narcosis.

20. Gas Log

The expedition Diving Safety Officer maintained a cylinder gas log updated daily by each diver following cylinder filling and analysis. The gas log recorded the following:

- Name of diver / cylinder user,
- cylinder capacity and application,
- cylinder serial number,
- date of fill,
- date and time of gas analysis,
- gas composition,
- maximum operating depth (based upon a 1.6 bar PO₂).

21. Analysis and Cylinder Identification

Each diver was responsible for analysing his or her own gases. Following analysis, every breathing gas cylinder was clearly labelled with the following:

- Maximum Operating Depth (MOD) in metres written in large bold numbers.

22. Rebreathers used

- a. Rod Macdonald Inspiration Vision CCR
- b. Paul Haynes ISC Megalodon Pathfinder CCR
- c. Emily Turton ISC Megalodon CCR
- d. Ben Wade ISC Megalodon CCR
- e. Marjo Tynkkynen ISC Megalodon CCR
- f. Prof Kari Hyttinen ISC Megalodon CCR
- g. Paul Toomer JJ-CCR
- h. Brian Burnett Inspiration Vision CCR

- i. Gary Petrie JJ-CCR
- j. Immi Wallin JJ-CCR
- k. Greg Booth Hollis Prism CCR
- l. Mick Watson JJ-CCR
- m. Prof Chris Rowland rEvo-CCR

18. APPENDIX II: Abbreviations Used in This Report

AGUF Anglo-German Underwater Filming Company

AP armour piercing

BL..... breech loading

BST..... British summer time

CCR..... closed circuit rebreather

DSMB..... delayed surface marker buoy

DST daylight saving time

END equivalent narcotic depth

GMT..... Greenwich mean time

GPS global positioning system

HE high explosive

IWM..... Imperial War Museum

MOD maximum operating depth

MoD Ministry of Defence

PDC..... personal decompression computer

PLB..... personal location beacon

PO2..... oxygen partial pressure

QF quick firing

ROV remotely controlled vehicle

SfM structure from motion

SONAR.... sound navigation and ranging

TEC The Explorers Club

UT universal time

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